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17. Protective Devices in Spiders' Snares, with a Description of seven New Species of Orb-Weaving Spiders. By Major R. W. G. Hingston, I.M.S., F.Z.S.

[Received March 22, 1927: Read April 5, 1927.]

(Text-figures 1–21.)

Introduction.

How spiders protect themselves is a neglected study. In this paper I intend to discuss the subject, and to show by what a number of remarkable devices the orb-weaving spiders secure this end.

That spiders have innumerable enemies is certain. The chief are parasitic hymenoptera and diptera. They are also preyed on by insectivorous birds. Bristowe refers to this point in his valuable observations on the spiders of Brazil. He thinks that wasps must destroy them in enormous numbers, so frequently did he find them in mud nests. He describes how a fly, *Plesiomma fuliginosa*, darts on and seizes Epeirid spiders while seated in the middle of their webs. My wasp chapters in 'Nature at the Desert's Edge' give some impression of the relentless persistency with which spiders are searched for and destroyed.

This paper is concerned only with orb-weavers. A brief acquaintance with this family of spiders discloses many ordinary methods of defence. Some kinds seem to need no protection, since they sit fully exposed in their snares. Many species hide under shelters or in crevices, and have a special connecting thread running from the shelter to the centre of the net. *Araneus mitifica* makes a tunnel of silk and comes out from it only when a capture is enmeshed. The most usual ruse is for the spider to drop. Some species drop only a short distance, hang for a while suspended on a thread, and when danger is past climb back to the snare. Other species fall completely to the ground, where they lie quite still simulating death. Some Epeirids look like lifeless objects. A *Cyclosa* at Baghdad spins against mud walls where it looks like a piece of clay; another species fixes its snare to the palm-trees and resembles a piece of bark. In India the *Tetragnatha* spin their webs over running water, anchoring them to plants and blades of grass. When alarmed, they remain perfectly motionless with the two front pairs of legs thrust forward and the two hind pairs thrust backward so as to bring them in line with the body. This attitude takes away their spider-like appearance and makes them resemble the flowers of the grasses which on all sides surround the snare.

Some orb-weavers are protectively coloured. This particularly applies to the genus *Argyroepeira* in India. They spin circular nets over bushes and vegetation. The spiders, though large, are not conspicuous. They hang back-downward from the centre of their snares. When looked at against the vegetation the ventral surface is visible, and this surface is ornamented with green bands which blend well with the foliage behind. When looked at from below the back is seen, and this surface is bright silver, which blends harmoniously with the sky overhead. A case of this kind, so striking in the field, makes one realize the necessity of arriving at conclusions from observations of spiders in their natural haunts.

Orb-weavers belonging to the genera *Gasteracantha* and *Micrathena* are probably in themselves sufficiently well-armed to resist ordinary attack. Their bodies are not soft like the generality of spiders, but more like that of an insect, hard and stiff, and with sharp spines projecting from the abdomen. When alarmed, they are accustomed to drop from their snares, fold in their legs, lie quite still, and look like inorganic lumps.

But more prolonged acquaintance with tropical species shows that, in addition to these ordinary methods, there are other more elaborate and complicated devices employed to fulfil the same end. They consist of various kinds of structures, chiefly pellets, bands, ribbons, and zigzags, manufactured by the spiders and woven into the texture of their webs. One can scarcely help regarding these devices as ingenious. They certainly are efficient in the highest degree. The amount of silk expended on them and the labour involved in making them indicate how intense is the struggle of spiders against parasitic diptera and wasps.

Classification of Devices.

A. The pellet device.

1. The string of pellets.
2. The pellet and hub.
3. The insect heaps.
4. The string of pellets with encircling ribbons.

B. The cylinder device.

5. The diametrical cylinder.

C. The band device.

6. The diametrical bands.
7. The diametrical bands with encircling ribbons.

D. The thread device.

8. The diametrical threads.
9. The cruciate threads.

E. The shield device.

10. The central shield.
11. The central shield with diametrical bands.

12. The central shield with spiral ribbon.
13. The oblique band.
14. The cruciate bands.

F. The cushion device.

15. The central cushion.
16. The central cushion with spiral ribbon.

G. The zigzag device.

17. The central zigzags.
18. The diametrical zigzags.
19. The cruciate zigzags.
20. The triradiate zigzags.

H. Foreign objects in snare.

21. The stick in snare.
22. The leaf in snare.

Description of Devices.

The String of Pellets. (Text-fig. 1.)

This device is made by a species of *Cyclosa* which I met with at Dharmsala, in the Dhauladhar Himalaya, at an altitude of 7000 feet. The spider is brownish-white in colour, but the shade varies greatly in different individuals. It makes a snare of the circular pattern usually against rocky cliffs.

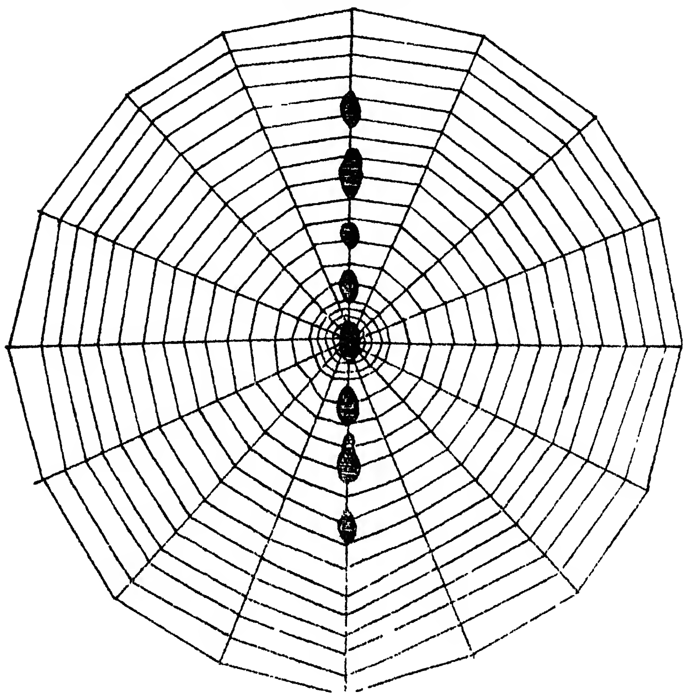
Its device consists of a string of pellets which it hangs along one diameter of the snare, almost always in the vertical direction. The pellets are made from captured insects which the spider wraps in a covering of silk. The number of these pellets varies. There may be four, five, six, or more, the number probably depending on the material available for making them.

The spider itself very closely resembles one of these pellets. It is roughly of the same size and shape, also of the same brown-white colour, and, when it tucks in its legs and remains motionless, it is very difficult to tell which is the spider and which the pellet. I have said that the spider's colour is variable; some are distinctly darker than others, and the pellets that these darker ones construct are correspondingly of darker hue. But, in addition to this close resemblance, the spider's position in the snare must be of great value, for it sits at the centre in the direct line of the row of pellets which are strung along the diameter on either side. So perfect is the resemblance that it is almost impossible to detect the presence of the spider unless it is remembered that it always remains at the centre of the snare. I showed the row of pellets to an observant friend and told him that one of them was a living spider. I asked him to select it, and offered a wager that he would not be correct in his selection. After a close scrutiny of the snare, he at length selected one of the pellets farthest away from the spider, and was

then very surprised to see the central pellet climb out along the snare as soon as I touched it.

Bristowe, in his Brazil paper, mentions a somewhat similar device in the case of *Cyclosa bifurcata.* But this spider constructs a chain of egg-cocoons, "covering them with a brown

Text-figure 1.



material and leaving a gap in the middle of the chain just big enough for the spider to fill. When sitting in this position it is very hard to see."

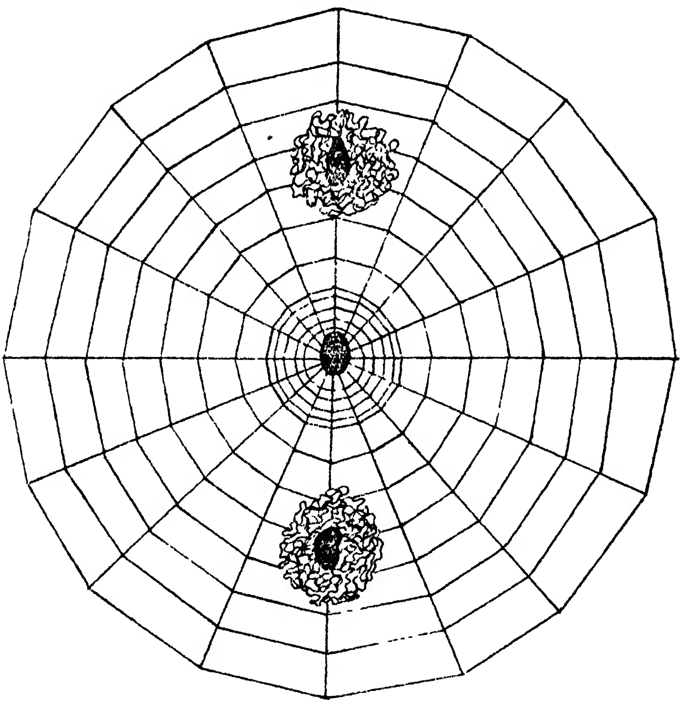
The Pellet and Hub. (Text-fig. 2.)

Cyclosa centrifaciens makes this device. It is an obscure small globular spider which I found at Akyab on the coast of Burmah. The snare is of the circular pattern, and the two examples I met with were spun upon trees. The point in it, however, of importance to us is the fact that it possesses a close-wound hub, the thread of the hub being quite distinct from the thread of the ordinary spiral.

The spider as usual sits at the centre surrounded by its close-wound hub. But at two points on one diameter of the snare,

each about half an inch on either side of the centre, it constructs a peculiar object which at first sight looks just like itself. A pellet is made, I suppose with silk and fragments of insects. It is about the same size and shape as the spider and of the same brown colour. So far the device is like the string of pellets. But the spider apparently is not satisfied with this. In addition it spins around each pellet a fine tangle of silk. It is not a spiral, but a confusion of threads, transparent, closely interwoven, and

Text-figure 2.



distinct from the viscid lines. This tangle is a representation of the spider's hub, a reproduction of the centre of the snare. Thus the spider in this case makes not only a pellet, but it goes a step further and makes a pellet plus a simulated hub. The spider, if it could, would, no doubt, make a true hub around its pellets. But this is an impossible operation, for in order to construct a hub there must be a radiating series of spokes. So it does the next best thing; it makes a tangle to simulate a hub.

All this, of course, adds to the spider's protection. An enemy is as likely to pounce on the pellet as it is on the spider at the centre of the snare. And, therefore, in this example of the snare

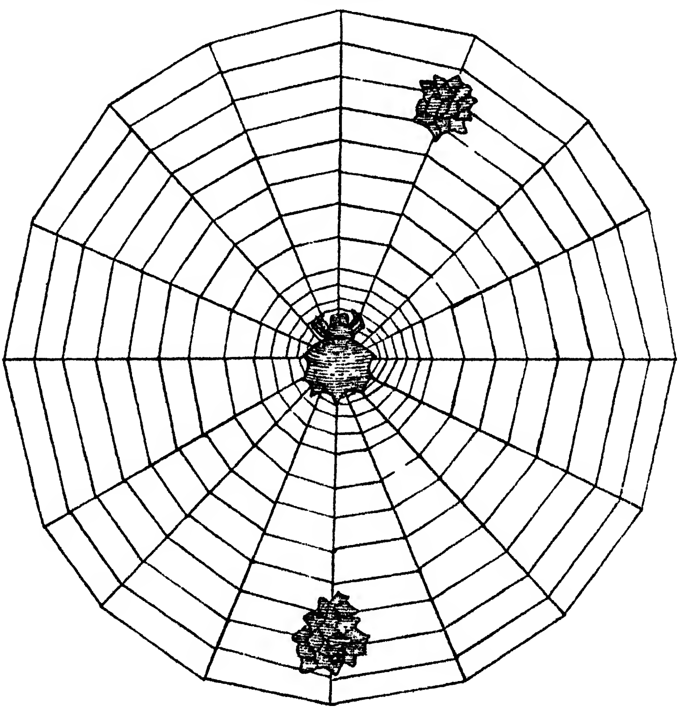
with two pellets, the spider has a two-to-one chance of escape. In another snare which came under observation there was an additional pair of pellets with hubs, placed, one on either side, external to the inner pair. This, of course, is still more efficient. The spider's chance of escaping the enemy is now increased to four to one.

That spiders should go so far in their devices in order to make these resemblances exact again shows how much they need some kind of protection when sitting in wait for insects in their snares.

The Insect Heaps. (Text-fig. 3.)

The species seems identical with *Gasteracantha brevispina* Dol. I found it in numbers at Port Blair in the Andaman Islands.

Text-figure 3.



It is a large, dark-coloured, conspicuous spider with hard stiff integument. The abdomen is broad and flattened, variegated with black and yellow markings and armed with six stout lateral spines. This spider sits in the centre of a large net usually

spread over exposed bushes. There is no attempt at any concealment. The net is placed quite in the open, and not, as in the case of allied forms, hidden in the dark recesses of a jungle.

The plan adopted by this *Gasteracantha* is to collect the bodies of its victims into heaps. Each heap may contain six, eight, or more captures. They have first been sucked dry, then wrapped up in silk, then bound together into these heaps. Each heap is about the size of the spider, of the same dark mottled colour, and irregular in outline which agrees with the spider's spiculated shape. The heaps are attached to the snare at variable distances from the centre. They are not, as in the case of the string of pellets, necessarily confined to one diameter, but may be attached to any of the spokes. The number of these heaps present in the web probably depends on the supply of captures. If these are few there may be only one heap, in other cases there may be two heaps, perhaps sometimes three or four.

The heaps are clearly of protective significance. From a little distance away it is difficult to tell which is the spider and which the heap. The spider is a flaky inorganic looking thing, and one has to inspect it at close quarters in order to distinguish it from the heaps. This increases the spider's chances of escape. The following kind of incident must frequently occur: A bird or a wasp sees the net. It makes a grab, but is as likely to strike at the heap as the spider. If the heap is touched the spider drops and escapes into the vegetation underneath. The heap is, therefore, a kind of decoy. One heap gives the spider even chances, two heaps a two-to-one chance of escape. The hard spiculated integument of this spider is probably in itself of protective value, but it cannot be a complete protection; for Bates found *Gasteracantha* in the nest of a *Pelopæus*, and Bristowe found the similarly armed *Micrathena* stored in the nests of a colony of *Tripoxylon*.

The String of Pellets with Encircling Ribbons. (Text-fig. 4.)

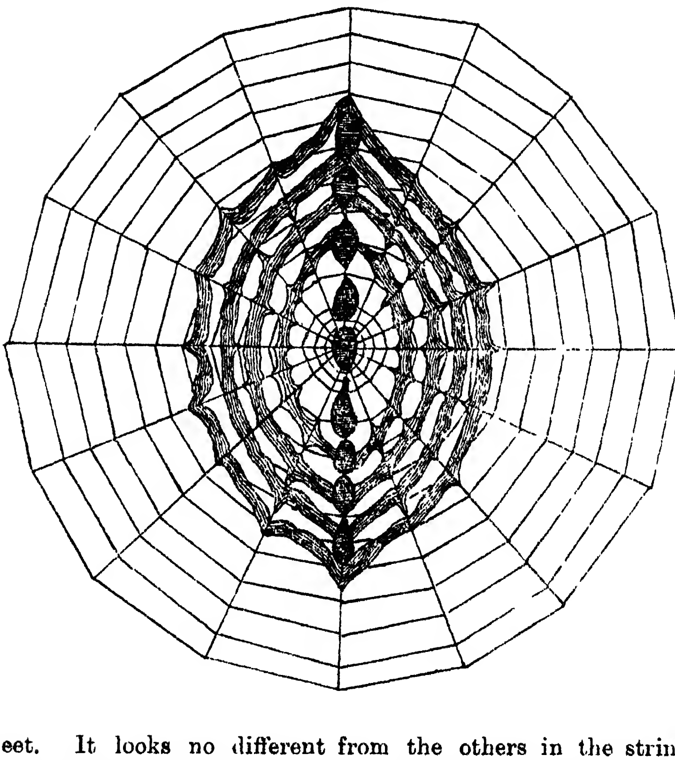
This *Cyclosa* goes a step further. It manufactures a string of pellets and combines this with encircling ribbons. I met with this spider in Northern India. It is small and obscure, in colour mottled-brown with a silver gloss on the back. The web is placed in a shady situation, such as a nook hidden by foliage or against the trunk of a tree.

The device consists of two separate portions. One part is the vertical string of pellets. They are made out of silk and insect fragments, but sometimes bits of seeds and leaves are incorporated. The spider probably employs whatever is available, any little object that sticks in the web may be woven into the string. The other portion is the series of ribbons. These ribbons are of quite a different appearance. They consist of four concentric ovals, situated one within the other, so placed as to surround the snare, and attached to every spoke. They are

white in colour, very conspicuous, and woven of innumerable threads. At each attachment to the radii these ribbons are drawn out into a point and this gives them a somewhat irregular appearance, or at least breaks up their even shape.

The spider is wonderfully hidden in the centre of this complicated system. I defy anyone to find it unless he knows that it occupies the central point. Touch the pellet where the radii

Text-figure 4.



meet. It looks no different from the others in the string. Nevertheless, it immediately becomes alive. It opens out, legs unfold, then it either drops like a stone to the ground or runs off along one of the threads. The elaborate contrivance is remarkably efficient. Though the whole arrangement is conspicuous enough, yet the spider is completely lost to view in this system of pellets and bands.

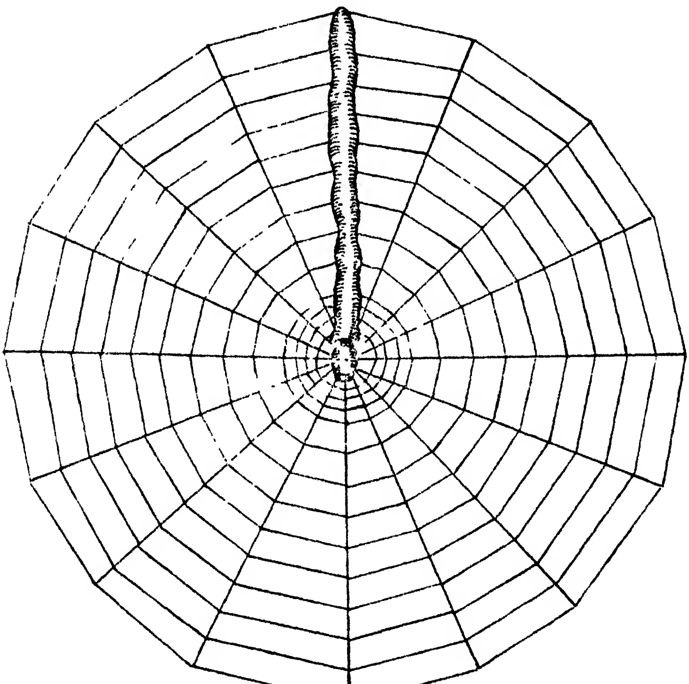
The Diametrical Cylinder. (Text-fig. 5.)

This is made by *Cyclosa cylindrifaciens*. I found it at Akyab on the Burmese coast. It is a small spider, yellow in colour with

black markings, mottled on the abdomen and speckled on the legs. The snare is of the circular pattern and is spun amongst mangroves on the coastal swamps.

Its protective device is a diametrical cylinder, not, as is more usual, a flat band-like structure, but a definite cylinder of silk. The cylinder is long and slender, compactly woven of yellow silk. Its surface is smooth, and the yellow colour is here and there speckled with black. The spider extends this cylindrical structure along the upper vertical radius of its web. It reaches from

Text-figure 5.



almost the centre to almost the circumference, and is anchored by a few threads to the upper foundation-line of the snare. The spider has made the cylinder about the same width as itself, and has so placed the structure that when it is seated at the centre of the snare it looks like a continuation of and part of the cylinder. The spider's colour, too, blends with that of the cylinder. In both the foundation colour is yellow relieved by blackish markings and spots. The spider ensures the perfection of its device by always sitting at the centre with the long axis of its body in line with the cylinder. No trace of the spider is then evident.

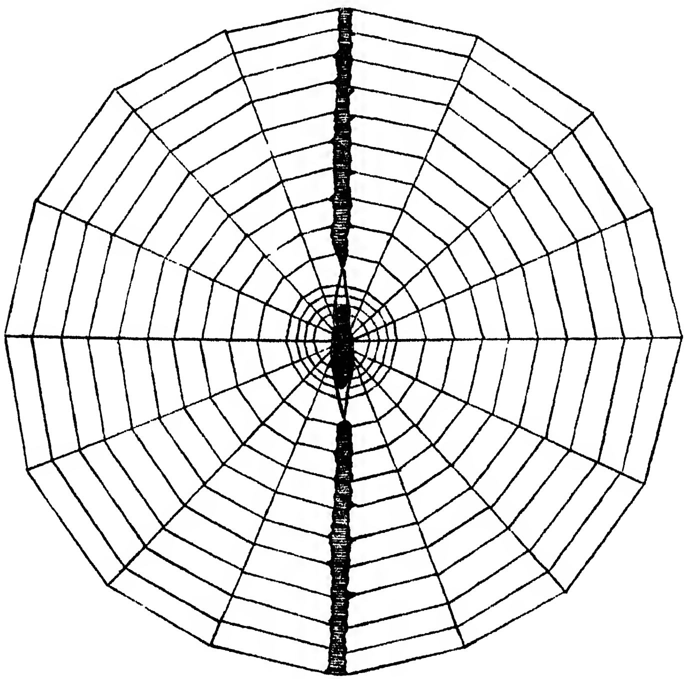
All that is seen is a long cylinder of which the spider forms one end. Certainly the device is highly protective. One may regard the spider as invisible so long as it sticks to its central seat.

The Diametrical Bands. (Text-fig. 6.)

Different species of *Uloborus* construct this device. A minute form, pale yellow in colour, is found in the date-groves at Baghdad. This spider spins a snare of the circular pattern, but of small size, not more than three inches in width.

Its device consists of a diametrical band, or rather two bands in line with one another, leaving a gap at the centre of the

Text-figure 6.



snare. The band is composed of matted silk, finely woven, delicate in texture, and conspicuous across the web. There is nothing zigzag in its appearance; it is just a plain, straight, flocculent band drawn out here and there to a lateral point by one of its anchoring threads. The position of the spider is of first importance in relation to the working of this device. For it takes up a position at the centre of the snare exactly in line with the diametrical bands. It fits neatly into the gap between

the two bands, and it has made the width of the bands equal to that of its own body. Moreover, it assumes an important attitude. The first and second pairs of legs are thrust out in front, the third and fourth pairs similarly thrust out behind, and the pairs on opposite sides are brought together so as to make them seem continuous with the body length. This attitude gives the spider a linear appearance and makes it appear part of the diametrical band. The whole adjustment is most perfect for the purpose of concealment. Each element is an essential part of it. The immobility of the spider, its position at the centre, its elongated attitude, its accurate adaptation to the length of the gap, its fixed attitude in line with the band, its width equal to that of the band, the colour of the band in harmony with itself, each of these is a necessary element in producing the concealing effect.

Uloborus ceniculatus, a common species on the plains of India, manufactures a somewhat similar device. This spider likes to spin on the hedges of cactus, attaching its threads to the long spines. The diametrical band is made of fluffy material. It stretches from the margin almost to the centre, but, like the Baghdad species, leaves a gap in the middle, just sufficiently large to take the spider's length. Concealment in this case is equally efficient; the shape, position, and attitude of *ceniculatus* being perfectly adapted to the band of fluff.

Gravely, writing of the genus *Cyclosa* in India, states that the webs frequently have a line of débris extending across one diameter with a gap in the centre which is exactly filled by the spider. This seems very like my diametrical ribbon. The resemblance is important. For *Cyclosa* and *Uloborus* are widely separated genera. They belong to the different families Argiopidæ and Uloboridæ. The case is, therefore, one of convergent evolution. Argiopids and Uloborids have evolved the same device for securing protection when seated in their snares.

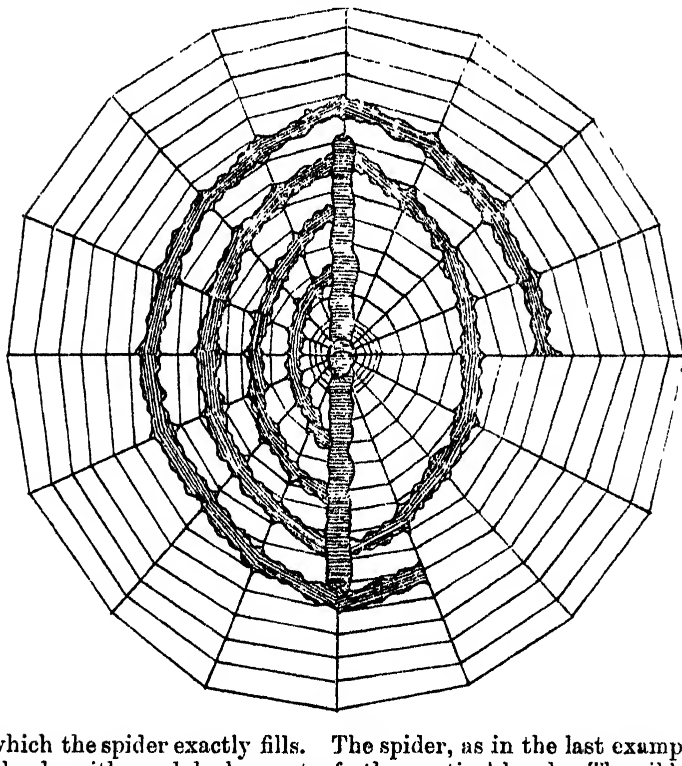
This convergence is illustrated in the United States also. Comstock, who names this band a stabilimentum, writes of *Cyclosa conica*: "The stabilimentum of *Cyclosa* differs greatly from that of a garden spider. It often consists largely of the remains of the insects that the spider has destroyed fastened together and in place with threads of silk. Frequently a cast skin of the spider is woven in with the insect remains; and bits of vegetation, as fallen bud-scales, are utilised. . . . Sometimes the stabilimentum consists entirely of silk. There is no retreat, the spider remaining constantly on the web. It rests on the hub in the centre of the stabilimentum, and appears like a part of the rubbish fastened in it." Then, again, he writes of *Uloborus americanus*: "On one occasion I had a brood of young of this species in a cage: each one made a stabilimentum across the centre of its web; but the parent spider had none in her web." Both the Argiopids and Uloborids of America have, therefore, evolved a stabilimentum.

The Diametrical Bands with Encircling Ribbons. (Text-fig. 7.)

This device is made by a small brown and silvery spider. I found it on the outskirts of thick jungle at Akyab on the coast of Burmah. The snare is of the circular pattern.

The device is an advance on the previous example. A series of encircling ribbons is added to the diametrical bands. The bands are made of finely comminuted débris. They are placed along the vertical diameter leaving a gap at the centre

Text-figure 7.



which the spider exactly fills. The spider, as in the last example, blends with, and looks part of, the vertical band. The ribbon arrangement is a strange innovation. I met with only one of these snares, and that one was probably incomplete. As shown in the figure, it had four ribbons on one side, and one and a half on the opposite side. Probably when the structure is finished there are four complete ribbons on each side of the snare. The ribbons are composed of white silky material, very conspicuous, with spiculated edges, and anchored to each successive spoke.

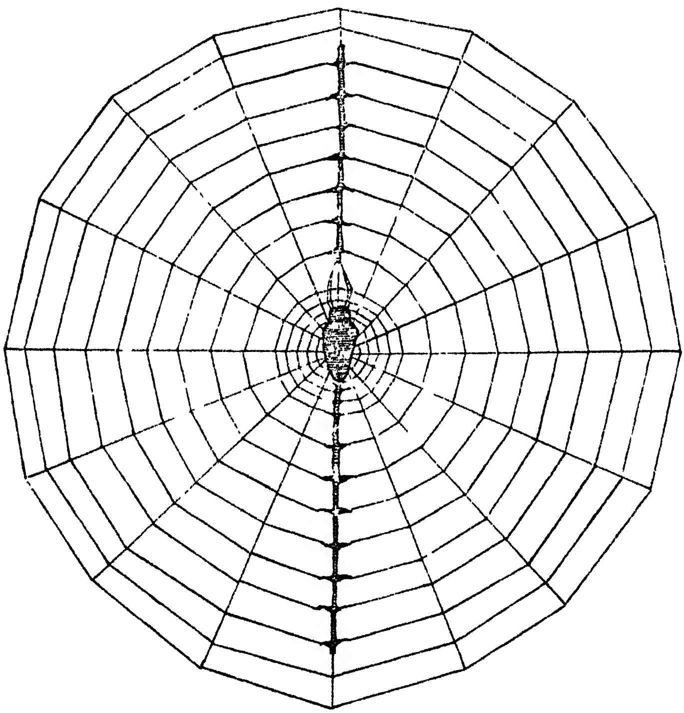
It reminds one of the system of pellets and ribbons. There

we had ribbons combined with pellets. Here the ribbons are combined with bands. In both cases the spider is equally well hidden in the centre of the complicated device.

The Diametrical Threads. (Text-fig. 8.)

This device is made by *Uloborus filifaciens.* It is met with at Port Blair in the Andaman Islands. The spider is small, rather angulated in appearance, and coloured in varied shades of brown. Its snare is of the circular type, four to five inches in diameter, and those which I found were on the roof of a hut made from the leaves of coconut-palm.

Text-figure 8.



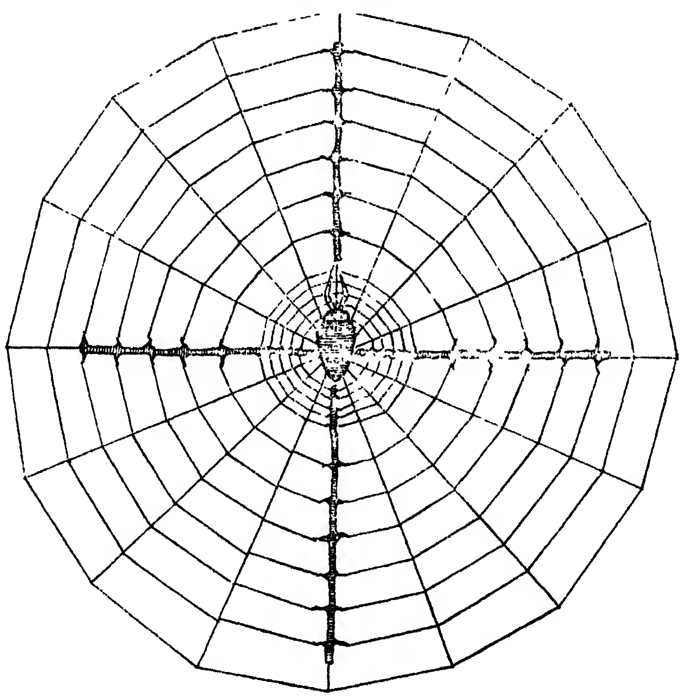
The device in the snare is a longitudinal thread extended along one diameter. Its ends reach almost to the margin of the snare. As in the case of the bands, there is a gap at the centre where the spider habitually sits. The thread is straight and thin, white, conspicuous, and much more obvious than the ordinary filaments of the web. It looks irregular owing to the presence of lateral tags which anchor it to the turns of the spiral.

This device reminds us of the diametrical band. There we had a spider fitting into a band and making itself invisible by blending with the band. Here the spider gets into a gap in a thread. It exactly fits the length of the gap; also it elongates itself by stretching out its legs, and this makes it seem continuous with the thread. But it does not blend so well as the *Uloborus* in the band. For this species is broader and more bulky than its thread. By its attitude it makes itself as slender as possible, but it cannot contract to the width of a thread. The device fulfils a double purpose, being partly a blending device and partly a confusion device. How confusion takes place I will describe later in cases where the principle is better displayed.

The Cruciate Threads. (Text-fig. 9.)

The spider is very similar, probably the same species as that which makes the diametrical threads. I found the two snares in close proximity under the roof of coconut-palms.

Text-figure 9.



The threads in this device are made into a cross. One thread is in the vertical, another in the transverse diameter. In

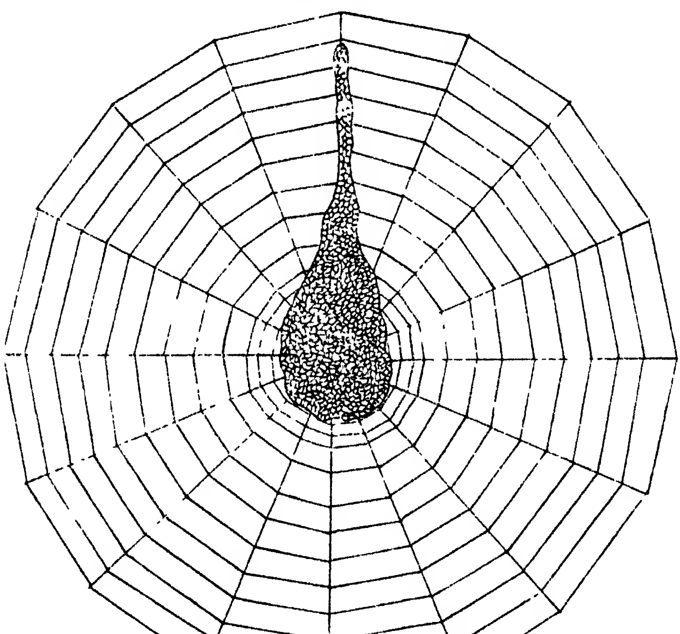
structure and appearance they are exactly similar to the example last described. A little point worth noting are the gaps at the centre. The gap left in the vertical thread is much larger than that left in the horizontal thread. The point shows us the neatness of these adaptations. For the spider has made one gap to fit the length and the other gap to fit the width of its body.

The Central Shield. (Text-fig. 10.)

This is the device of *Uloborus scutifaciens*, which I met with at Akyab in Burmah.

The shield consists of a kind of mat placed at the centre of the snare. It is composed of fine particles of débris interwoven with silk. In the illustration given the shape of it is triangular

Text-figure 10.



owing to one end being drawn out along the vertical radius. But in other examples it is rounded or more irregular. Moreover, it is not necessarily a layer: more often it is a jumbled heap of débris, insect-fragments, and silk.

The spider makes use of this mat as a shield, which serves the

purpose remarkably well. For the shield is many times larger than the spider, and the spider habitually sits behind it. The position of the snare is important in this respect. For it is spread against the trunk of a tree, and, consequently, when the spider gets behind its shield, it becomes concealed from outside observation by sitting between the shield and the bark. Moreover, the spider blends with its shield, being the same mottled-brown colour as the collection of débris and silk. This plan of concealment is very perfect. When a snare of this kind is found against a tree-trunk, the shield, of course, is conspicuous enough, but not a trace of the spider can be seen.

An Epeirid, which I met with on the Everest Expedition, also adopts the shield principle in order to get protection in its snare. This species is found on the Tibetan plateau at a height of 15,000 feet. It spins a circular snare on thorny bushes and sits at the centre of the web. At the central point it makes a shield, not, however, like the one just described, an intermixture of silk and débris, but just a thin circular mat of semi-translucent silk. This is, therefore, a more primitive and less efficient protection. The snare is almost vertical; the spider sits at the centre with its ventral surface up against the shield. In this position it is fairly well concealed from view, but not in the same complete manner as in the case of the shield composed of silk and débris.

Here, again, we see an instance of convergent evolution. A *Uloborid* and an *Argiopid* have both evolved the central shield method of defence.

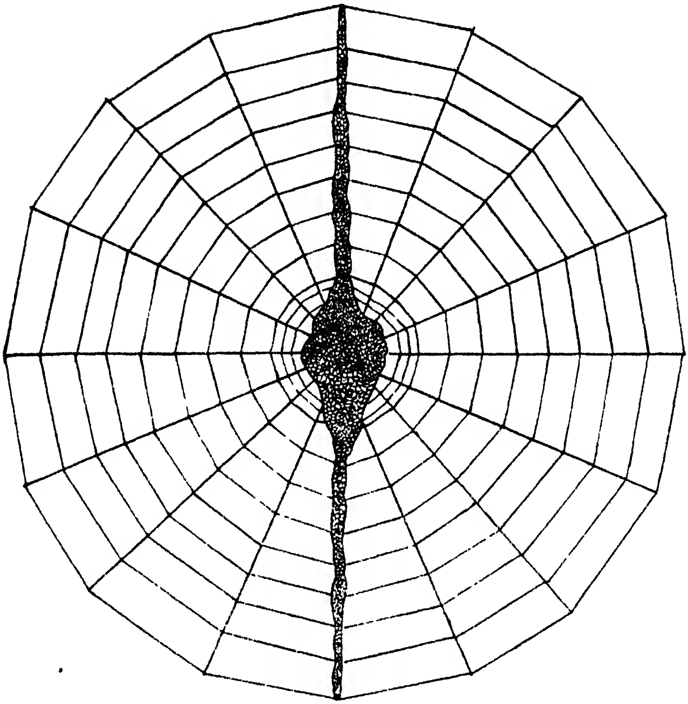
The Central Shield with Diametrical Bands. (Text-fig. 11.)

Uloborus scutifaciens, the last-mentioned species, makes this slightly more elaborate device. It is a small brown spider, with silvery markings and distinct black bands across its legs. I found the snare at Akyab in Burmah. It was the orthodox pattern, about four inches in diameter, and situated in hollows on the trunks of trees.

It had a central shield as in the last example. The shield was composed of a silken tangle. It was very much larger than the spider which sat on one side of it and blended with its surface. The snare was placed obliquely, in fact, almost horizontally, in the large crumbling hollow of the tree. The spider kept to the under surface of its shield, and was, therefore, completely concealed from above.

The advance of this device on the last example consisted in a prolongation of the shield into diametrical bands. These bands were carried out along the vertical radii and were composed of the same loose silky texture as the shield. It is possible that this and the last example may represent two separate stages in the manufacture of the same device.

Text-figure 11.



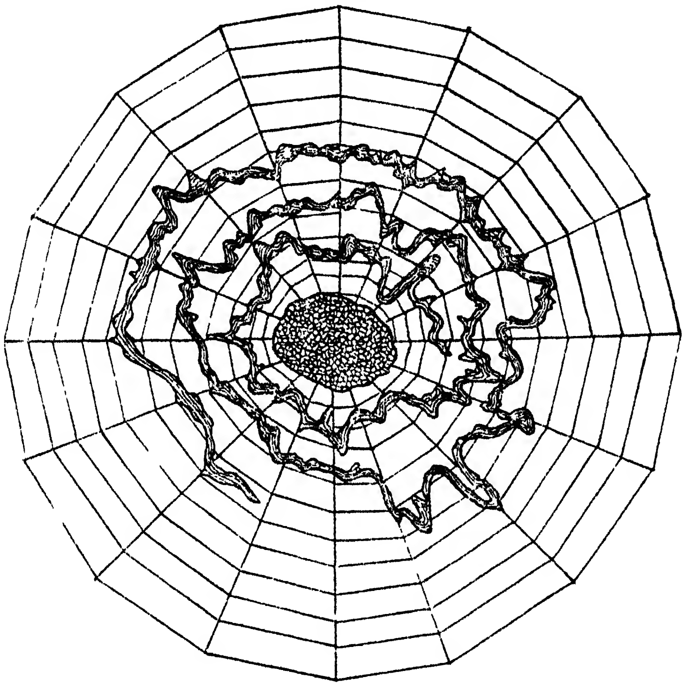
The Central Shield with Spiral Ribbon. (Text-fig. 12.)

A very similar *Uloborus* makes this device. It also inhabits Burmese jungles and places its snare in the hollows of trees. The snare is set obliquely and is quite small, only about two inches in width.

The spider makes a central concealing shield. It is a closely woven silk mat, either oval or circular in shape, and sufficiently opaque to hide the spider, which hangs on underneath. In addition the spider manufactures a ribbon. This is a distinctly irregular structure, narrow and band-like, fairly conspicuous, twisted into a roughly spiral arrangement, and anchored by threads to the radiating spokes. This employment of some kind of encircling ribbon seems a frequent combination with other devices. We saw a system of ribbons combined with pellets, a somewhat similar system combined with bands; here we have one arranged around a central mat, and later I will describe one twisted round a cushion. All, I have no doubt, fulfil the same purpose. They draw attention away from the spider at the centre, and in this way improve the efficiency of its device.

Perhaps the best name for this type of structure would be a "dispersing device." Encircling ribbons and encircling spirals

Text-figure 12.



both come into this category. Their conspicuousness serves to disperse attention by drawing the eye outwards from the centre of the web.

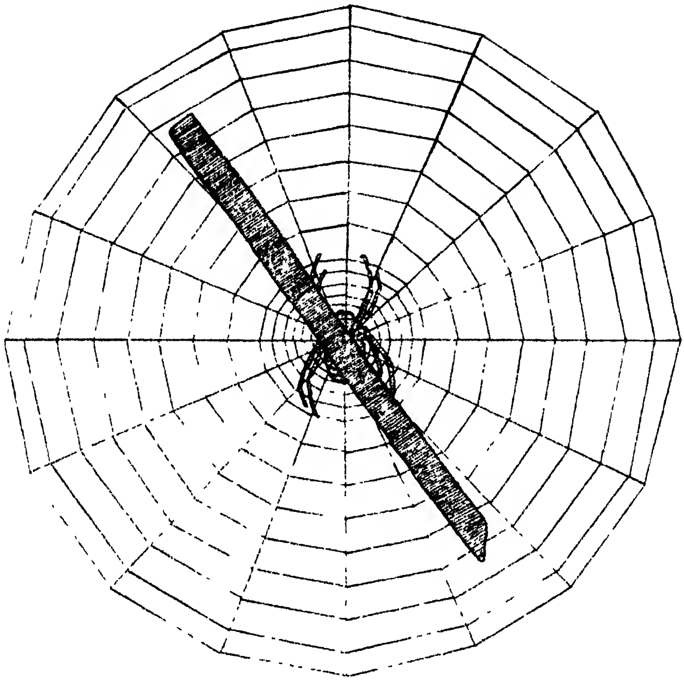
The Oblique Band. (Text-fig. 13.)

This device is made by *Uloborus crucifaciens.* It, too, was met with at Akyab in Burmah. The spider is small, brown and silvery above, but variegated on its ventral surface. Its snare is circular, about three inches in diameter, and placed vertically against a tree-trunk in the jungle. The spider, as is customary, sits at the centre, where it assumes an attitude like that of *Argiope.* Its legs are arranged in pairs and spread round it in the form of a cross.

Its device consists of a white band of silk stretched obliquely across the snare. It is a sharply defined compact strap, broad and straight, and with even edges. It is very conspicuous, being composed of pure white closely-woven silk. This strap is about the width of the spider's body, and is stretched right across the centre of the snare. The spider sits behind the strap, that is

between the strap and the bark of the tree. Its body is concealed by the device; only its legs appear thrust out on either side of the strap. Obviously this is a concealing device. We have seen before how *Uloborus* spiders construct bands with gaps in the

Text-figure 13.



middle, then put themselves into the gaps where they appear part of the bands. But this band is on a different principle. It goes right across the centre without leaving a gap. It is, therefore, not in any way a blending device, but a shelter behind which the spider can hide.

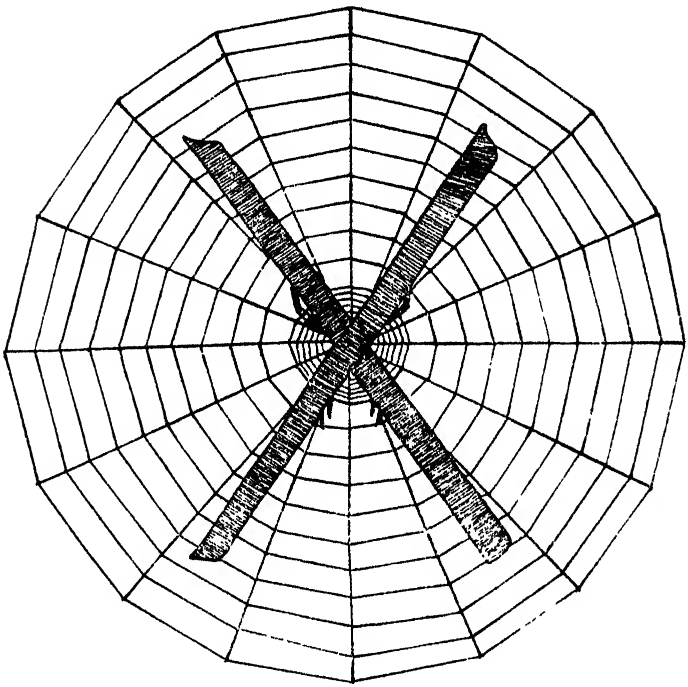
The Cruciate Bands. (Text-fig. 14.)

The oblique band may be an incomplete structure. In the same locality I found another snare with two bands arranged in the form of a cross. This may be the complete device of which the oblique band is only a part. But I think that they are distinct arrangements. At any rate, the oblique strap is permanent for a time, and of protective value while it exists.

The cross device was made by *Uloborus crucifaciens.* The cruciate bands make a perfect shield. The spider's body is completely hidden. In the oblique band arrangement the spider's

legs were visible: in the cruciate system only their tips appear. Now we see the reason for the spider's attitude, its legs collected together in pairs and spread round it in the form of a cross. By this special posture it hides itself more perfectly, for it manages to get a pair of legs behind each of the crossing straps. We have had other illustrations of this interesting relationship, the

Text-figure 14.



adoption of the spider of some particular attitude to suit the requirements of its device. There was the *Cyclosa* that folds itself to look like a pellet, the *Uloborus* that elongates itself to fit into a band. Here we have a *Uloborus* that makes itself cross-shaped in order to get behind a cruciate contrivance, and later we will see that an *Argiope* does the same in order to be continuous with a zigzag cross.

The Central Cushion.

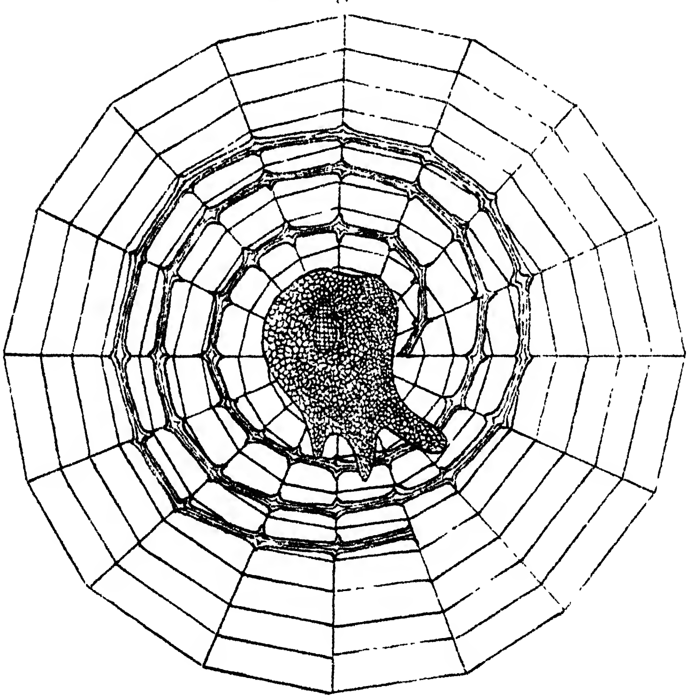
I have no illustration of this device, which is a very simple kind. It is made by a minute species of *Cyclosa* which I met with at Fyzabad in Central India. The spider collects the remains of its captures and heaps them together at the centre of its snare. It keeps them in position with threads of silk which bind them into an irregular mass. This collection of material

I call the cushion. It is greyish in colour, chiefly on account of the silk contained in it. It hangs loosely from the centre of the network, and on it the spider is accustomed to rest. The spider's colour is mottled-grey, similar to that of the cushion of débris. Moreover, it is so minute that it appears quite insignificant when compared with its bulky seat. As a consequence it is excellently hidden. From the cushion it stretches out its legs, takes the radii in the tips of its tarsi, and in this way maintains communication with its snare. But its body remains concealed on the débris. On looking at the snare we see the cushion plain enough, but it looks just like a lump of ragged tissue of which the spider forms part. The cushion must not be confused with the shield. The central cushion is a blending device; the spider sits exposed on it. The central shield is a concealing barrier the spider gets behind it, that is between it and the tree.

The Central Cushion with Spiral Ribbon. (Text-fig. 15.)

This is more complicated than the last example. A spiral is wound round the concealing cushion. It is made by another

Text-figure 15.



species of *Cyclosa*, a small brown spider with a silvery gloss on its back. I found it at Akyab in Burmah, where the web was

spun amongst mangroves in the swamps along the coast. The web was of the circular pattern and six inches in width.

At the centre is the cushion of débris, a large, flat, mottled layer on which the spider rests. Its colour is an intermixture of grey and brown which blends well with the variegated pattern of the spider. In fact, the spider is practically invisible when clinging to this central lump. But the cushion does not seem to be sufficient for this species. In addition a spiral has been manufactured, a kind of dispersing device. The spiral is a white conspicuous band, composed of silk, not much thicker than a stout thread, and twisted three times round the central seat. Where it crosses each spoke an anchorage is made, and this gives it an irregular appearance by drawing it out into pairs of tags. Though only a thin band, it is remarkably distinct, standing out in striking contrast against the ordinary filaments of the web. Its function is to disperse the vision by carrying the eye from the centre of the snare.

The Central Zigzags. (Text-fig. 16.)

I pass now to another series of devices which consists of zigzags introduced into the snare.

The first, which I call the central zigzags, is made by a minute Argiopid spider which I met with in Northern India. Its web is small, two inches in diameter, and supplied with an extensive hub.

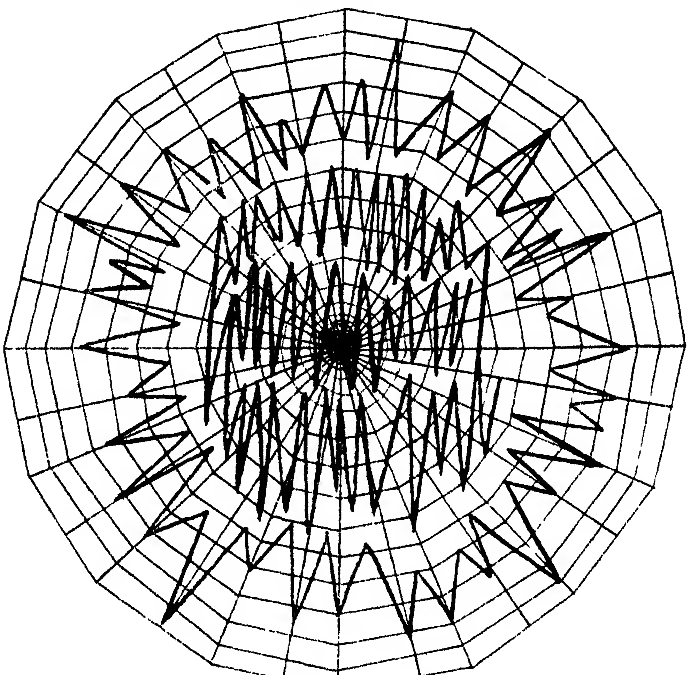
Its remarkable feature is the system of zigzags, which are arranged in an elaborate and complicated manner. There is, first of all, an extraordinarily angulated thread spread in a circle round the web and attached to every radius. It is drawn out into sharp points, and certainly has a confusing outline. In addition it is composed of white material, more conspicuous than, and quite different in appearance from, the ordinary transparent filaments of the snare. This, however, is only part of the arrangement. The centre of the web is simply massed with zigzags. For the most part they are spread from side to side, but they overlap one another and are intermingled, and have obviously not been constructed with any special geometrical care. They cover the whole of the central area, enveloping the spider's habitual seat in a dense confusion of angulated lines.

This is a remarkable protective device. The spider, of course, sits at the centre, but is hidden in the midst of the angulated confusion. When we look at the web we plainly see the device. But all that we notice is a white maze, a confusing pattern of angulated threads. We see nothing of the spider at the centre. Its shape and outline are completely lost in the midst of this zigzag maze.

Comstock, in 'The Spider Book,' gives a photograph of a web belonging to *Metargiope trifasciata*. In this photograph we see a central massing of zigzags, not unlike that shown in my illustration, but without the zigzag spread circularly round them.

This photograph is of considerable interest. It fits in well with our previous systems. We had pellets by themselves, then pellets with ribbons round them; we had bands by themselves, then bands with ribbons round them: we had a shield by itself, then a shield with a spiral round it; we had a cushion by itself, then a cushion with a spiral round it; now Comstock shows a central massing of zigzags, while my example has the central massing together with a zigzag ribbon round it. How strong is this

Text-figure 16.



instinct in different families of spiders to twist some kind of spiral or circular ribbon around the less elaborate protective device!

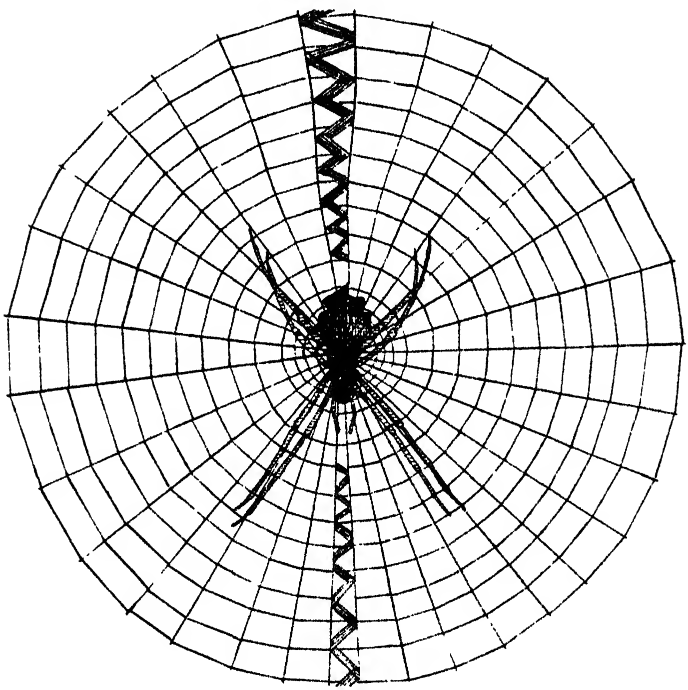
Comstock, who saw this central massing of zigzags in the United States, calls the structure a stabilimentum. He regards it as a ribbon for strengthening the snare. But this, I feel sure, is a wrong interpretation Hosts of spiders make webs without any of these devices, and such webs seem quite strong enough. Moreover, I have given numerous examples of the time and labour that spiders must give to this problem of concealment within the web. I am certain that the object of the zigzags is

protection. The structure not only conceals the spider, but in addition draws attention away from it. For, on looking at the snare, the eye is confused, and is drawn away from other objects by the vivid conspicuousness of the zigzag threads.

The Diametrical Zigzags. (Text-fig. 17.)

This is the device of *Argiope clarki.* It is a large and powerful spider, three inches long including the legs. The most striking thing about it is the flattened abdomen, triangular in

Text-figure 17.



shape, and margined with blunt points. In connection with the device its colour is important. The whole dorsal surface glistens like silver; the ventral surface is mottled with yellow and brown.

This spider spins its snare in the palm-groves of Baghdad. It is spread over a bush or between the trunks of the palms. The net is immense. quite two feet in diameter, and slung by long anchoring threads. It is placed almost vertically, but with a slight inclination, and the spider remains at the under surface of the slant. The spider's position is at the centre with its raking

legs spread around it. The legs are collected into pairs, one pair being formed by the first and second leg, the other pair by the third and fourth. The two legs in each pair are kept close together, and the pairs are arranged like the limbs of a cross.

This spider's device consists of a zigzag placed in the vertical diameter of the snare. It is quite different from the ordinary filaments, being a broad and prominent ribbon, white in colour, and very conspicuous. The zigzag is stretched out on either side of the centre to a distance of about half the diameter of the snare. The centre is left free of the structure. The angular points that compose the zigzag are closely and fairly regularly laid. They average about sixteen to the inch, and I counted seventy-four in the ribbon stretched along one radius. The structure is inserted between a pair of radii to which it is fixed by the tips of its angles. On these radii it exerts a strain, with the result that they are brought closer together than those in other parts of the snare.

An immense number of silk threads go to compose this zigzag ribbon. They are massed together like fibres in a rope. At the edges of the ribbon the structure is more open, the threads appearing as if spread apart, but in the middle they are closely woven into an opaque layer. The zigzag must be an important structure so great is the expenditure of silk in making it. One which I pulled out straight measured as much as two and a half feet.

There must be some valuable end secured to repay so much labour and expenditure of silk. The gain to the spider is in protection. The zigzag is a confusion device. The ribbon attracts immediate attention, not only because of its white colour, but even more on account of its angulated shape. It is a distinctly more prominent feature in the network than is the spider at the centre of the snare. As a consequence it literally absorbs attention. The result is that notice is withdrawn from the spider, while the zigzag, by appearing continuous with its body, gives it an unnatural and unspider-like shape. We must also remember the blend in colour. The spider's back glistens like silver, and the zigzag ribbons, which appear to run into it, have the same bright silvery glint.

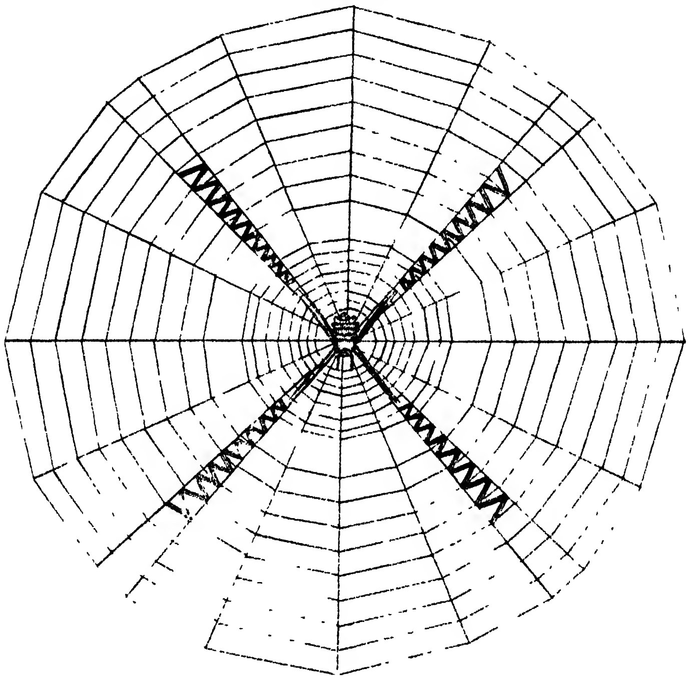
The Cruciate Zigzags. (Text-fig. 18.)

This is made by *Argiope pulchella* of India, and forms almost identical with it. It is a smaller spider than *Argiope clarki*, but quite conspicuous and brilliantly marked with yellow, olive-black, and silver. I found its snare in the jungles of Northern India, spun in secluded places beneath the shelter of large trees. Like *A. clarki*, it sits in the centre with head directed towards the ground and legs arranged similarly in pairs.

This species also puts zigzag ribbons in its snare. They are white-silvery angulated structures like those in the web last

described. But this species distributes its zigzags differently. They are not placed in the vertical diameter, but arranged, like the letter X, in four diverging limbs that radiate from the centre of the web. Each limb occupies about two-thirds of a radius, not reaching all the way out to the circumference, and also falling short of the central point. They are applied tightly and draw the radii together; indeed, the radii at times may be brought almost into contact, so great is the binding strain. In

Text-figure 18.



the snare they appear in the form of a cross, the limbs of which are evenly separated, showing that the spider has taken specia care to fix them at equidistant points.

The attitude of the spider is of special importance in relation to this cruciate device. Its legs are spread around it in pairs, and each of these separate pairs is in line with a limb of the zigzag cross. There is no variation in this relationship. The spider always assumes this attitude, and legs and limbs always coincide. The relationship is of obvious importance. It means that the spider so fixes its body that its outstretched legs appear continuous with the ribbons. In fact, the whole apparition—the combination of the spider and the ribbons—is that of a large conspicuous cross. The structure is, therefore, a confusing

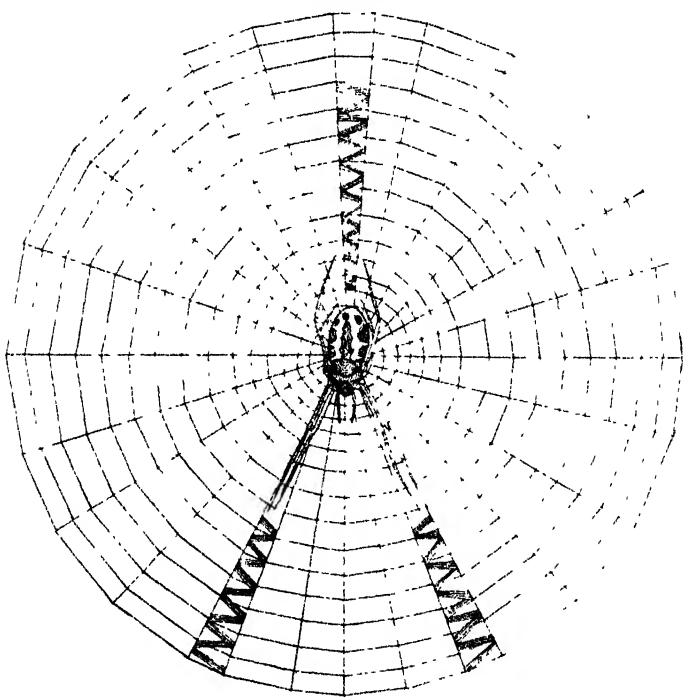
device. Through its presence the outline of the spider is lost. The spider looks part of the complicated zigzag, and no longer appears like a living thing. The plan is more perfect than in the last example. Here the spider is lost in the centre of a cross, there it was part of a vertical line.

Bristowe writes of *Argiope argentata*, which also manufactures a zigzag ribbon: "The advantages of this ornamentation are not very clearly understood; but when the spider sits in the centre of its web, as is its custom, its silver body is made much less conspicuous because of this similarly coloured background."

The Triradiate Zigzags. (Text-fig. 19.)

This is a particularly interesting example. It proves unmistakably that the zigzags are protective, and shows in a delightful

Text-figure 19.



manner how protection is brought about. The species is *Argiope catenulata* Dol. It is a large spider, one and a half inches long, with an oval variegated abdomen and raking banded legs. I found it at Akyab in Burmah. Its snare is large in proportion, about two feet in width, and was spun amongst trees growing

near the coast. It adopts the usual *Argiope* attitude, body vertical, head turned downward, legs collected into pairs, and spread around it in the form of a cross.

This species, unlike those previously described, places three zigzag ribbons in its snare. One zigzag is above, in the vertical diameter; it seems as if a prolongation of the spider's abdomen, a kind of long zigzag tail. The other two zigzags are directed downward. They diverge as they descend, and look as if they were a prolongation of the two front pairs of legs. These zigzags conform to the usual appearance, being silvery-white, band-like, conspicuous, and drawing close together the pairs of radii between which they are attached. They extend across the snare for some two or three inches, leaving, of course, a clear space at the centre in which the spider sits.

Now look at the spider's coloration. On its dorsal surface is a pattern of silver, exactly the same glistening colour as the zigzags. The silver is spread uniformly over the thorax, but on the abdomen it is arranged in three irregular bands. One of these bands is central, runs longitudinally along the middle line, and thus forms a silver continuity with the vertical zigzag ribbon in the snare. The remaining two bands are lateral, one along either side of the dorsal surface of the abdomen. Their continuity is with the lower zigzag ribbons through the intermediation of the front pairs of legs. Thus the spider's colours are adapted to its zigzags. There is no doubt about the camouflage. It is quite beyond question when seen in the field. The silver on the spider is so conspicuous: just as bright as that of the zigzag. Also the pattern is so suitably arranged. Furthermore, the bands are irregular or broken, which makes them fit in with the zigzag effect.

This example must confirm our belief that these zigzags are of protective and not structural significance. Their purpose is to conceal the spider and not to strengthen the web. *Argiope clarki* has a uniformly silver back because it has to blend with a line of zigzags; in this species the silver is arranged triradially because it has to blend with a triradiate device. It is all a case of harmonization. These large spiders must live in open spaces. They must have wide areas for spreading such big snares. They have few natural objects to blend with. Hence this remarkable solution. Silvery structures are manufactured, devices that fit in with their styles of ornamentation, arrangements to break up their spider-like appearance, to make them just a part of a system of zigzags, and unlike living things.

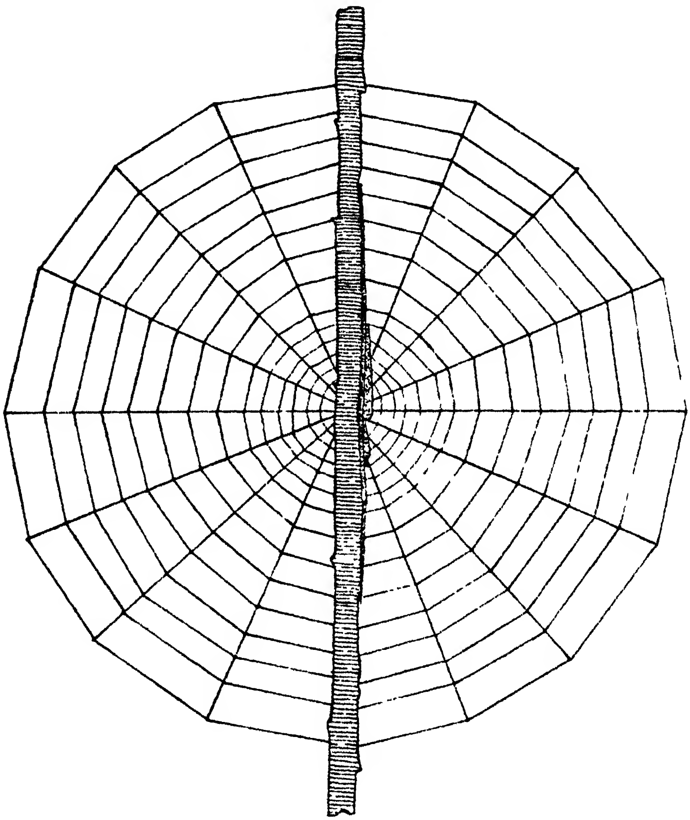
The Stick in Snare. (Text-fig. 20.)

I now come to two examples of spiders which protect themselves in a different way. Instead of manufacturing their own devices they make use of some extraneous object which they keep within the snare.

In this first example the foreign object is a stick. The spider involved is *Tetragnatha baculiferens.* It was very common at

Akyab in Burmah. It is a slender, elongated, brownish-coloured spider. The body-length of an average one is about half an inch, but the legs are so raking and attenuated that when stretched out backwards and forwards they increase the length to as much as two inches. The snare is of the usual circular pattern. I found numbers spread on bushes in the shelter of thick jungle, and in every instance the same method of protection was used.

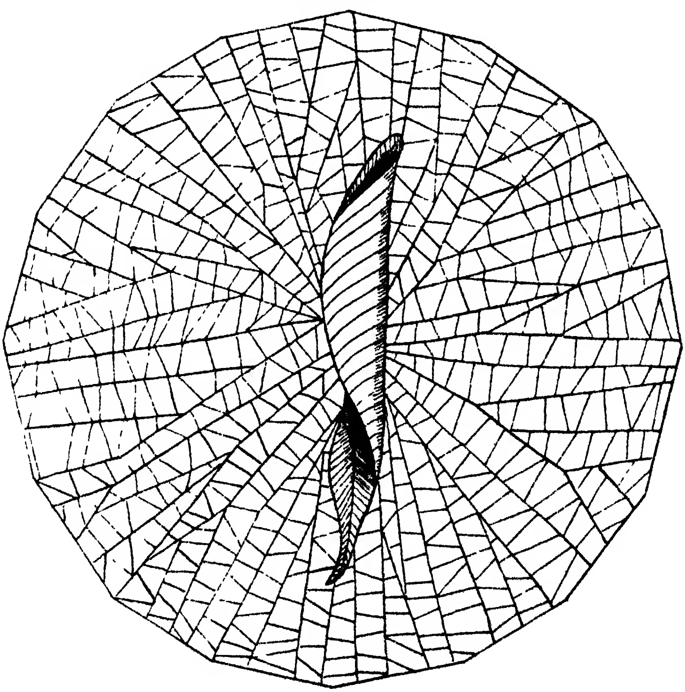
Text-figure 20.



The ruse is simple, ingenious, and efficient. The spider always spins its net around a piece of withered stick. As a rule it so arranges its snare that the stick is aligned along one diameter. That is the type given in the illustration. But less often the stick is placed to one side, stretched along the edge of the snare. In the more usual diametrical arrangement the stick, of course, runs through the centre and divides the snare into equal halves. The spider sits at the centre of the web and aligns itself along the stick. Its first and second pairs of legs, which are

long and raking, are thrust out far in front and pressed down against the stick; the third pair are short and clasp the support; the fourth pair are moderately long and are thrust out behind. The spider's body is slender, elongated, mottled; it is pressed, like the legs, tight against the stick, with which it exactly blends. The result of all this is invisibility of the spider except under the closest inspection. The spider becomes just a line or a ridge on the stick, and all that is seen is the straight stem with the half snare on either side. When the snare or stick is touched the spider remains motionless. Its instinct is to rely on harmonization. It behaves as if it knew why it lay along the stick. Closer interference makes it more alert. It runs out along the stick or drops to the ground. When the stick is placed along one edge of the web the spider sits on it in the same way. The arrangement must be less advantageous for the spider. A position at the edge is less favourable than at the centre, for at the centre the spider feels all its radii, and is therefore more sensible of the slightest vibration coming from every part of the snare.

Text-figure 21.



The Leaf in Snare. (Text-fig. 21.)

This is the plan of *Tetragnatha foliferens.* It is a yellow-brown spider with long slender legs and in body-length about half an

inch. I found it in numbers at Nankauri in the Nicobar Islands. The snare is a much more irregular pattern than is usually made by Epeirid spiders. Its radii and spirals are spread rather disorderly; there is none of that striking parallelism and symmetry so characteristic of the circular web. The snare is made triangular in shape. It is large, may be as much as two feet in diameter, and is spread amongst vegetation in the gloom of the tropical jungle.

This spider employs a leaf for its defence. The leaf is attached to the snare near the centre. It is folded longitudinally into a tube. The edges are fastened together with silk, and the whole interior of the tube is lined with a layer of the same material. In this way the spider makes a tunnel open at both ends. The spider remains within this tunnel, where it is completely concealed from view. When the snare is touched it slips out from its hiding-place, and can escape in either direction since it has an exit at both ends. The instant it emerges it drops to the ground, where it is lost to view. I have little doubt that the spider collects its leaf and carries it into the snare.

Conclusion.

It will be instructive to summarize these various contrivances in accordance with the principles under which they act.

The principle of the decoy is illustrated by the pellets: the blending principle by the cylinder or diametrical bands. We see the principle of confusion illustrated by the zigzags, the principle of dispersion by the encircling ribbons; simple concealment by the cruciate bands. Then we notice how one device may combine two principles. In the string of pellets with encircling ribbons both decoy and dispersion operate. In the diametrical bands with encircling ribbons dispersion is combined with a blending device. The principle of concealment is associated with dispersion in the central shield with spiral ribbon. The triradiate zigzags combine a confusion and a blending device.

The following table is a classification of these devices according to the principles under which they act:—

A. Decoy devices.

- The string of pellets. (Text-fig. 1.)
- The pellet and hub. (Text-fig. 2.)
- The insect heaps. (Text-fig. 3.)

B. Blending devices.

- The diametrical cylinder. (Text-fig. 5.)
- The diametrical bands. (Text-fig. 6.)
- The central cushion.
- The stick in snare. (Text-fig. 20.)

C. Confusion devices.

- The diametrical threads. (Text-fig. 8.
- The cruciate threads. (Text-fig. 9.)
- The central zigzags. (Text-fig. 16.)

D. Concealing devices.

The central shield. (Text-fig. 10.)
The central shield with diametrical bands. (Text-fig. 11.)
The oblique band. (Text-fig. 13.)
The cruciate bands. (Text-fig. 14.)
The leaf in snare. (Text-fig. 21.)

E. Decoy and dispersion device combined.

The string of pellets with encircling ribbons. (Text-fig. 4.)

F. Blending and dispersion device combined.

The diametrical bands with encircling ribbons. (Text-fig. 7.)
The central cushion with spiral ribbon. (Text-fig. 15.)

G. Concealing and dispersion device combined.

The central shield with spiral ribbon. (Text-fig. 12.)

H. Confusion and blending device combined.

The diametrical zigzags. (Text-fig. 17.)
The cruciate zigzags. (Text-fig. 18.)
The triradiate zigzags. (Text-fig. 19.)

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Description of Certain New Species of Spiders mentioned in this Paper.

1. *Spider making pellet and hub device.*

Cyclosa centrifaciens, sp. n.

Cephalothorax black, smooth, shining. Legs pale yellow with brown spots. Eyes in two parallel lines, almost equal, extremities in apposition, anterior line recurved and with distance between median eyes less than between median and lateral eyes, posterior line almost straight and with distance between median eyes less than that between median and lateral eyes, ocular quadrangle a little longer than broad and broader in front than behind. Abdomen, seen from above, triangularly ovate, from the side, quadrate with a tendency to bifurcate posteriorly, mottled, brown and reddish brown intermingled with yellow or grey.

Total length 3·5 mm.

Loc. Akyab in Burmah.

2. *Spider making diametrical cylinder.*

CYCLOSA CYLINDRIFACIENS, sp. n.

Cephalothorax black or reddish black, smooth, shining. Legs reddish brown, distinctly banded with yellow, one very broad band on femora, two bands on tibiæ and tarsi, in some specimens legs almost completely yellow with the red reduced to a few spots. Eyes in two parallel lines, almost equal, extremities in apposition, anterior line recurved and with distance between median eyes about equal to that between median and lateral eyes, eyes of posterior line almost straight and with distance between median eyes less than that between median and lateral eyes, ocular quadrangle almost equal in length and breadth, but distinctly broader in front than behind. Abdomen, seen from above, oval, triangular when seen from the side, broad and truncate in front, conical posteriorly, with a pair of blunt tubercles, one on each side, on dorsal surface rather more than one-third the distance from the anterior end, profusely mottled in pale grey and reddish brown, but with much variation in depth of colour.

Total length 4 mm.

Loc. Akyab in Burmah.

3. *Spider making cruciate threads.*

ULOBORUS FILIFACIENS, sp. n.

Cephalothorax reddish brown with whitish or yellowish pubescence. Legs reddish brown with indistinct pale bands. Eyes in two lines, posterior line recurved, distance between median eyes of posterior line greater than that between median and lateral eyes. Abdomen, seen from above, triangularly oval, quadrate when seen from the side, elevated in front, with raised blunt tubercle on each side of middle of dorsal surface, reddish brown on sides, but with profuse whitish or yellowish fascia on dorsal and ventral surfaces, this fascia absent along middle line in anterior half of dorsal surface, leaving broad reddish-brown longitudinal band with sinuous margins, but dense in posterior half, where it is greyish or whitish.

Total length 3 to 4 mm.

Loc. Port Blair in Andaman Islands.

4. *Spider making central shield.*

ULOBORUS SCUTIFACIENS, sp. n.

Cephalothorax black with thin whitish fascia, thicker round the eyes, a median whitish longitudinal band on dorsal surface in posterior third and similar band along lower margin of lateral surface. Legs black, becoming paler and reddish on tarsi, marked with conspicuous yellow bands, the band on tibiæ of front legs particularly broad. Eyes in two parallel lines, almost equal, anterior line almost straight, and with distance between

median eyes less than that between median and lateral eyes; eyes of posterior line slightly recurved, and with distance between median eyes a very little greater than that between median and lateral eyes; ocular quadrangle a very little broader than long, more distinctly broader behind than in front. Abdomen ovate, on dorsal surface in middle line about one-third from anterior end a median blunt rounded tubercle with summit bare of fascia, olive-brown, with white fascia thin on lateral and ventral surfaces, in some specimens uniformly thick on dorsal surface, in other specimens dense in anterior third, but scanty or absent in posterior two-thirds.

Total length 5 to 7 mm.

Loc. Akyab in Burmah.

5. *Spider making oblique band.*

ULOBORUS CRUCIFACIENS, sp. n.

Cephalothorax pale dusky yellow, with white fascia fairly thick on sides, thin dorsally, a bare area behind the eyes clear of fascia. Legs darker, light brown, with indistinct pale band on tibiæ. Eyes of posterior line large, prominent, distinctly procurved, distance between median eyes a very little, if at all, greater than that between median and lateral eyes; ocular quadrangle a very little longer than broad and somewhat broader behind than in front. Abdomen ovate, elevated anteriorly where it has a blunt tubercle on either side, dorsal surface pale yellow or whitish with three minute black spots in a longitudinal row on either side, ventral surface with median dark band and pale laterally.

Total length 4·5 mm.

Loc. Akyab in Burmah.

6. *Spider placing stick in snare.*

TETRAGNATHA BACULIFERENS, sp. n.

Cephalothorax about half again as long as broad, reddish brown with yellowish hairs. Mandibles reddish brown. Legs paler, yellowish brown. Abdomen four times as long as broad, long, almost cylindrical, brown, with pale markings more distinct on dorsal surface. Eyes in two parallel lines with extremities in apposition, anterior line slightly recurved and a little shorter than posterior line, which is straight; ocular quadrangle broader than long, distinctly broader posteriorly than anteriorly; median eyes of anterior line a little nearer to one another than to lateral eyes: median eyes of posterior line a very little nearer to lateral eyes than to one another. Mandibles moderately long but shorter than cephalothorax, projecting downwards and forwards and distinctly divergent. Fang long and curved.

Total length 8·5 mm.

Loc. Akyab in Burmah.

7. *Spider placing leaf in snare.*

TETRAGNATHA FOLIFERENS, sp. n.

Cephalothorax about half again as long as broad, yellow with pale yellow hairs. Mouth-parts and legs pale yellow. Abdomen twice as long as broad, narrowly ovoid, fairly thickly covered with pale golden hair, dorsal surface in posterior half with a lateral longitudinal line of four to five brown spots, under surface with hour-glass-shaped dark brown patch. Eyes in two parallel lines with extremities of lines close together, anterior line almost straight, shorter than posterior line, which is slightly procurved, ocular quadrangle a little broader than long, a very little broader anteriorly than posteriorly; median eyes of anterior line a little nearer to lateral eyes than to one another; median eyes of posterior line farther from lateral eyes than from one another. Mandibles short, scarcely twice as long as broad, directed sharply downwards, stout and cylindrical at base, narrowing to apex. Fang short and gently curved.

Total length 10 to 16 mm.

Loc. Nankauri in Nicobar Islands.

18. Microscopical and Bacteriological Investigation of the Water in the Society's Aquarium. By Flaxney P. Stowell, B.Sc., Ph.D., A.I.C., and Vernon J. Clancey, A.R.C.S., B.Sc.

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The physical and chemical conditions existing in the sea- and fresh-water circulations of the Society's Aquarium have already been discussed (Stowell, Proc. Zool. Soc. of London, 1925, p. 1241, and *ibid.* 1927, p. 19). Consequently, a microscopical examination of the waters already investigated chemically and physically is an extremely useful addition to the data already existing, especially as such an examination often confirms the results of a chemical analysis, or detects indications of pollution or contamination which are too small to affect such an analysis, and which might consequently be overlooked. Although it is impossible even for an expert to identify all the living constituents of a water sediment, the presence or absence of certain species affords valuable indications as to the purity of a water. A considerable number of organisms, however, afford no indication, as they are present in almost all waters. Often associated with pollution are *Sphaerotilus natans*, *Leptomitus lacteus*, *Beggiatoa alba*, *Euplotes patella*, *Cryptomonas* and *Carchesium lachmanni*, and a few of the Oscillatoria group. For greater detail, classifications, etc., the reader is referred to 'The Microscopy of Drinking Water' by Whipple (London: Chapman & Hall, Ltd.). Non-motile Oscillatoria are rarely found in unclean waters, whilst certain of the motile forms are said to be very characteristic of polluted waters. Consequently, a water of high chlorine and albuminoid ammonia content, and also found to contain organisms such as above mentioned, is almost certainly being polluted from some source. If, however, Oscillatoria, for example, were found to be present, it would be very rash to condemn the water on the grounds of the biological examination alone, as the results of chemical examination might indicate by low ammonia and chlorine values, etc., a water of high chemical purity. From this line of argument, it will be seen that whereas it is unwise to arrive at a hasty conclusion as to the condemnation of a water on the results of a chemical or biological examination alone, the combination of chemical and microscopical investigations is extremely useful in interpreting the conditions existing in a water and its suitability as a healthy medium.

In addition to the broad identification of the various forms of microscopic life existing in the Aquarium water, the examination

of samples from different points in the circulation affords valuable information as to the effectiveness of the filtration and storage methods employed, and confirms the conclusions arrived at by the physical and chemical investigations.

Though the danger arising from a polluted water is due not so much to the organic matter in suspension or solution, but to bacteria, too great importance must not be laid on the results of a bacteriological examination, since their interpretation is very varied. It is only within recent years that any definite standardization of method has been attempted, and such rigid care is necessary with regard to the method of collecting and transport of the water sample, the time and temperature of incubation, and the method of colony counting, that it is not surprising that utterly divergent results are often obtained by different workers on the same sample. Even with concordant results, the history of the water and its source must be known before the results can be interpreted. The identification of the bacteria ordinarily living in any water is also an extremely difficult and unnecessary task. Consequently in the present examination, no attempt was made to isolate and identify any particular species, especially as an immense number of different species of bacteria are found in water, and the majority have no known significance, being apparently quite harmless. If a water is known to be causing a definite epidemic, the isolation and identification of the particular species causing that epidemic must be attempted, but for all ordinary purposes a count of the number of organisms capable of growth on gelatine and agar in definite periods of time (that is, ordinary and "blood-heat" organisms) is all that is necessary. Counts taken on samples from different points of the circulation are particularly useful in determining the efficiency of filtration and storage as bacterial purifiers.

Various workers have stated that dark storage is quite as efficient as storage in sunlight for the elimination of bacteria. Assuming this to be true, the advantages of dark storage from a physical and chemical point of view were pointed out in a recent paper by one of the authors (Stowell, Proc. Zool. Soc. of London, 1926, p. 245). In the present investigation, bacterial counts have proved that dark storage in the Aquarium reservoir for a month eliminated over 90 per cent. of the bacteria found normally in the show-tanks.

The Sea-water—Microscopical and Biological Examination.

For a general examination of samples from various parts of the circulation, as a preliminary to an accurate count, about a litre of the sample was filtered through half an inch of fine sand contained in a filter-funnel and kept in place by a roll of fine copper gauze. The first 250 cubic centimetres were filtered twice. The sand was then washed into a small tube with about 5 cubic centimetres of distilled water. The 5 c.c. thus contained the

organisms originally present in the litre of sample. Drops were submitted to microscopical examination.

Samples from the various show-tanks were found to be remarkably free from organisms. Minute organic débris was present—*diatoms, infusoria, amœbæ,* and *cyclops.* As the counts show later, the numbers are remarkably few. Attached to the glass in various show-tanks was a small worm-like organism, identified as a young polychæte of the family Eunicides. Of the protozoa, there was no indication of the presence in the water of any of the organisms usually identified with organic pollution.

On the rock-work and outflows from the show-tanks there is a greenish-brown growth found to consist of green and brown algal and fungal hyphæ, containing vast numbers of the organisms which were found in relatively few numbers in the actual water. A representative sample contained diatoms, small worms, amœbæ, oscillatoria, and infusoria, including *Euplotes patella.*

Samples of the water collected from the filter-beds contained organic débris, infusoria, various algal cells, and spirella. Scrapings of the sand revealed the presence of rotifera, infusoria, amœbæ, diatoms, and encysted forms of various protozoa.

The red deposit in the glass nozzles through which the water enters the tanks contained particles of sand and hydrated ferric oxide, also diatoms No traces could be found of the iron bacteria *Crenothrix polyspora*, and inoculation of suitable media with samples of water from various rust-scrapings in the circulation gave negative results.

Reservoir-water samples undergoing sedimentation revealed no organisms and practically no minute débris.

Enumeration of Micro-Organisms.

The organisms in one litre of each sample were concentrated to 5 cubic centimetres by the accurate application of the method described in the preceding section. 1000 cubic centimetres of the water were filtered through half an inch of fine sand, as before, and the sand containing the deposit was washed into a tube with exactly 5 cubic centimetres of distilled water. A cell (of which the exact depth was known) mounted on a microscope-slide was filled with a sample of the concentrate after vigorous shaking and ultimate settling of the sand-particles, and a count taken of the micro-organisms within the field of the objective throughout the depth of the cell. As the area of the field of the objective is accurately known, the enumeration of the number of organisms in one cubic centimetre of the sample is a simple calculation. Table I. gives a comparison of the counts obtained from the four main points in the circulation, viz. show-tanks, filter-bed, outflow from filter, and reservoir.

TABLE I.

Enumeration of Micro-Organisms in the Sea-water Circulation.

Counts are expressed in number of organisms per cubic centimetre of water

Organism.	Show-tank.	Filter-bed.	Outflow from Filter.	Reservoir standing 18 days.
Amœbæ	8	1	Nil.	Nil.
Infusoria	100	18	,,	,,
Diatoms	24	13		,,
Encysted Protozoa ..	12	6		,,
Spirella ..	—	—		,,
Unicellular Algæ ...	32	14	,,	,,
Minute débris and sand-particles	800 approx.	1600 approx.	300 approx.	200 approx.

It will be seen from the above table that the actual water is remarkably free from organisms. Another rather unexpected result is the fact that the filter-bed water, which one would expect to hold by far the largest number of organisms, contains a smaller number than the show-tanks. It is apparent that the algal growth lining the outflows acts as a very efficient preliminary filter for organisms. Sand-filtration, as would be expected, removes the few micro-organisms which pass through the overflow, and any sand-particles passing from the filters to the reservoir are finally settling to the bottom.

The Fresh-water Circulation—Microscopical Examination.

The same method of procedure was adopted for the fresh-water circulation as for the sea-water—a general qualitative examination, followed by an exact count. Here, again, most of the organisms were found to be adhering to the algal and fungal growths on the sides and outflows of the show-tanks—the actual water being relatively free from microscopic life. A few traces of diatoms were found in the show-tanks, with diatoms, amœbæ, infusoria, and algal cells in the filter-bed surface-water, with sand and minute organic débris.

The algal growths in the outflows, however, contained an abundance of microscopic life, particularly fresh-water diatoms. Amœbæ, infusoria, fungal hyphæ, and algal threads and cells, shells of minute crustacea, and small worms were also present in practically all the cases examined. Diatoms far exceeded in number any other form of organism.

As would be expected, the growth in the tropical fresh-water tanks yielded most evidence of microscopic life, owing to the higher temperature of the medium. All the above forms were

present, together with larvæ and encysted protozoa. The growth on the sides of the tank containing *Pterophyllum scalare*, which renders it such an attractive exhibit, was particularly rich in diatoms and desmids (*Scenedesmus* and *Arthrodesmus*), also rotifera, *Euplotes patella*, *Cryptomonas*, and *Carchesium lachmanni*. The water itself in the tropical tanks was relatively rich in organisms, compared with the ordinary fresh-water tanks, as shown by the count in Table II.

Enumeration of Organisms.

Table II., like Table I., yields a comparison of the counts obtained from show-tanks, filter-bed water, outflow from filter and reservoir. It should be mentioned that as the fresh-water circulation includes only one reservoir, which is always included in the circulation, the effects of sedimentation are not so marked as in the sea-water counts.

TABLE II.

Enumeration of Micro-Organisms in the Fresh-water Circulation.

Counts are expressed in number of organisms per cubic centimetre of water.

Organism.	Show-tanks	Filter-bed	Outflow from Filter.	Reservoir	Tropical Show-tanks.
Amœbæ	Nil	1	Nil.	Nil.	3
Infusoria	,,	16	,,	,,	14
Diatoms ...	40	37	,,	,,	10
Rotifera .	Nil.	Nil.	,,	,,	7
Encysted Protozoa .	6	10	,,	,,	3
Unicellular Algæ .	1	24	,,	,,	40
Minute debris and sand-particles .	1000 approx.	1600 approx.	300 approx.	250 approx.	1400 approx.

The fresh-water circulation exhibits a behaviour similar to that observable in the salt-water circulation, with the exception that diatoms are more abundant. The effect of filtration is obvious. The retention of the organisms by the algal growths will be discussed in a later section of this paper. A count for the water in the angel-fish tank has been included to show the effect of temperature on the multiplication of micro-organisms more or less absent in the ordinary show-tanks.

Bacteriological Examination.

As already mentioned, the different species of bacteria present in water are exceedingly numerous. Most are of the harmless type, and the classification of a large number of them has been

undertaken by various workers. For an ordinary routine bacteriological examination of a water, an attempt at classification of these organisms is a tedious and unnecessary task, and the matter of primary importance in an analysis and the criterion of the suitability of a water—for, say, human consumption—is the detection of any bacteria usually associated with pollution. Examinations may also be undertaken to determine the efficiency of any method of water purification, such as storage, filtration, or chemical treatment. In such cases, a count of the number of organisms in a given volume of the water, capable of growing on gelatine and agar at a definite temperature, is necessary. It is also essential in the case of an epidemic to detect and identify, if present, the specific organism responsible for that epidemic, if water-borne.

An organism invariably present in sewage or waters liable to sewage-pollution is the *Bacillus coli*. It is found in the excrement of human beings and also of birds, fish, and reptiles. Bacteria closely allied to the *Bacillus coli*—that is, bacteria of the intestinal type—will consequently be found in any water which is known to be open to sewage pollution, and, whereas their presence in any quantity in waters destined for human consumption is highly undesirable, it is inevitable that in waters containing large numbers of fish (such as in an aquarium) there will be present some bacteria of this class. The problem which interests us is more to what extent bacteria are removed by the processes of filtration and storage. If filtration and storage reduce the total number of bacteria present to any considerable extent, it is certain that objectionable bacteria will also be reduced.

Standards as to the number of organisms to be found in a definite volume of the water capable of growing on nutrient gelatine at 20°–22° C., and their ratio to the number growing on nutrient agar at 37° C, have been laid down by various writers, but so much depends on the source of the water and its history that these standards are widely divergent. According to Thresh, it is probably safe to say that a filtered water should contain fewer than 100 organisms per cubic centimetre capable of growing on gelatine at 22° C. in three days. An indication is also afforded as to the presence or otherwise of liquefying or proteolytic organisms. The ordinary standards of purity of a water for human consumption from a bacteriological point of view cannot be laid down to the same extent, however, in the present case. It is probable that the bacteria which are harmful to fish-life are those which are capable of growth on gelatine or agar at 18°–20° C., as the normal temperature of fish is very little above that of the water in which they live. Since the death-rate in the Society's Aquarium is so low, it is clear that there are no epidemic diseases due to bacteria, and the problem resolves itself into an investigation as to what extent the bacteria present are removed by the purification methods employed in the Aquarium, from the point of view of their bacteriological efficiency as

compared with the chemical. Counts have been made of the number of bacteria per cubic centimetre capable of growing on nutrient gelatine and agar at 18°–20° C. and at 37° C. respectively, in samples taken from the show-tanks, and also after filtration and after prolonged dark storage. The counts at 37° C. indicate the number of human intestinal bacteria, etc., or "blood-heat" organisms which may have had access to the water through external contamination, and also the extent of their removal by the purification processes. In addition to the counts on gelatine at 18°–20° C., counts have been undertaken on agar at the same temperature for the larger quantities of water (1·0 c.c. and 0·5 c.c.), which contained too many liquefying organisms to permit of a 48- and 72-hour count on gelatine.

As already stated, great discrepancies are sometimes observed in counts taken from samples of the same water, owing chiefly to the method of counting. Some investigators count only colonies visible to the naked eye, whilst others use a low-power lens. Hence it is quite easy to see that unless the conditions

TABLE III.

Bacterial Counts on Gelatine and Agar for Samples from the Sea-water Circulation.

Sample.	Colonies on Gelatine at 20° C. in 72 hrs.		Colonies on Agar at 20° C.		Colonies on Agar at 37° C.	
	Non-Liq.	Liq.	48 hrs.	72 hrs.	24 hrs.	48 hrs.
Tank.						
1·0 c.c.	Totally liq.		500	900	72	145
1·5 c.c.	"	"	265	492	50	78
0·05 c.c.	45	5	—	—	—	—
0·02 c.c.	20	3	—	—	—	—
After filtration.						
1·0 c.c.	Totally liq.		108	260	48	96
0·5 c.c.	"	"	61	125	23	50
0·05 c.c.	10	1	—	—	—	—
0·02 c.c.	3	Nil.	—	—	—	—
Reservoir standing 28 days.						
1·0 c.c.	Semi-liquefied.		82	150	3	10
0·5 c.c.	"	"	39	79	1	3
0·05 c.c.	7	1	—	—	—	—
0·02 c.c.	Nil.	Nil.	—	—	—	—
Reservoir standing 42 days.						
1·0 c.c.	—	—	50	89	1	3
0·5 c.c.	—	—	26	48	nil.	1

TABLE IV.

Bacterial Counts on Gelatine and Agar for Samples from the Fresh-water Circulation.

Sample.	Colonies on Gelatine at 20° C.		Colonies on Agar at 20° C.		Colonies on Agar at 37° C.	
	Non-Liq.	Liq.	48 hrs.	72 hrs.	24 hrs.	48 hrs.
Tank.						
1·0 c.c.	Totally liq		over 1000	over 2000	250	420
0·5 c.c.	,,	,,	400 about	1000 about	120	195
0·05 c.c.	120	13	47	150	—	—
0·02 c.c.	58	5	—	—	—	—
After filtration.						
1·0 c.c.	Totally liq.		125	320	46	78
0·5 c.c.	,,	,,	47	175	25	41
0·05 c.c.	10	1	5	12	—	—
0·02 c.c.	5	1	—	—	—	—
Reservoir.						
1·0 c.c.	Totally liq.		130	100	83	133
0·5 c.c.	,,	,,	50	190	39	61
0·05 c.c.	16	2	6	13	—	
0·02 c.c.	6	1	—	—	—	-

ruling the count are explicitly stated, a large number of discrepancies may enter. In the present investigation, the following procedure was adopted: –

Separate portions of 10 c.c. of nutrient gelatine and agar were plated in sterile Petri dishes for each sample. In the agar counts, 1·0 c.c. and 0·5 c.c. of the water were added after thorough shaking of the sample, and in the gelatine counts 1·0, 0·5, 0·05, and 0·02 c.c. After admixture by gentle rocking, the samples were incubated at 20° C. and 37° C. for gelatine and agar respectively. As already stated, it was found that the larger quantities of the sample (1·0 and 0·5 c.c.) liquefied gelatine completely, so that these quantities were later plated on agar at 20° C., in order to ascertain the total number of organisms. Counts of the colonies visible to the naked eye were taken after 24 and 48 hours at the higher temperature, and after 48 and 72 hours at the lower temperature. The samples investigated were taken from both fresh- and sea-water circulations, from the same points (viz., show-tanks) after filtration and after storage. In the case of the fresh water, storage is only of a day or two's duration, as the fresh-water reservoir is in continuous use. Table III. gives the bacterial count on gelatine and agar for the salt-water circulation, and Table IV. analogous results for the fresh-water. The values given are the representative average of numerous counts.

Discussion of Results.

Before passing to a detailed discussion of the results cited above, it will perhaps be advisable to give a brief *résumé* of the method of water-circulation employed in the Aquarium. The sea-water supply is contained in two concrete underground reservoirs, each of 60,000 gallons capacity, one reservoir being included in the circulation for a month or six weeks, while the water in the other is dark-stored. At the end of this period, the reservoir which has been in circulation is cut out and the recently stored water brought into use. Since it is not necessary to exercise quite as much care over the conservation of the fresh-water supply, as pure fresh water is easily obtainable, only one underground reservoir is included in the fresh-water circulation, aeration and filtration being relied upon for purification.

From these reservoirs, the supply is pumped up to a smaller high-level reservoir. It is then forced by gravity into the show-tanks through glass-lined iron pipes terminating in small glass nozzles. From the show-tanks the water is conveyed to the filters, where it is sprayed over a surface of sand. After passing through fifteen inches of the latter, it passes directly into the underground reservoir. The sea-water circulates at the approximate rate of 50,000 gallons in twenty-four hours, whilst the fresh water is slower, being approximately 42,000 gallons in the same time. The water in the tropical tanks, which are fed from a separate high-level reservoir, passes through the same filters and low-level reservoir as the ordinary temperate fresh water, but is passed through the exhibition-tanks at a rate of 26,000 gallons in twenty-four hours

Turning to the microscopical and biological results, the first point noticeable is the comparative freeness of both salt and fresh water from micro-organisms (other than bacteria) at all parts of the circulation. This must be attributed to three causes—(*a*) filtration, (*b*) storage and sedimentation, and (*c*) the retention of organisms in the algal and fungal growths lining the show-tanks and outflows. We will deal with each in turn.

A sand-filter when first started acts merely as a coarse strainer, but after a few days' use algal growths weave filaments through the mass, diatoms and zooglœa fill the interstices, and gradually the filter becomes an efficient agent of purification. So far as the larger micro-organisms are concerned, it will be seen from the above results that their passage is effectually retarded by the filters. Minute masses of organic débris, which accumulate in the show-tanks, especially after feeding, are also removed, and practically all that passes into the storage reservoir are minute particles of silica. Sedimentation during storage effects their removal in turn, by deposition. From the microscopical point of view, storage seems almost unnecessary. It must be remembered, however, that the benefit of storage after filtration, from a

chemical point of view, has already been conclusively demonstrated (Stowell, Proc. Zool. Soc. of London, 1926, p. 245). Filtration cannot, of course, remove soluble organic matter, and it is from the oxidative processes taking place during the dark storage, and the conversion of this organic matter into nitrate, that one of the most important purification-factors of storage is apparent. The bacteriological results, to be discussed later, also indicate how essential is the latter to the maintenance of a healthy medium.

It is in the algal growths lining the tanks and outflows that by far the largest proportion of the micro-organisms living in the water is retained. This growth is densely matted, and the vast majority of the organisms abounding in it are protected from the circulation of the water. Those organisms which are washed out from the growth find their way to the filter-beds, where they are arrested.

Both sea and fresh water growths contain diatoms, but the diatom-colonies are much more plentiful in the fresh water. Amœbæ and many infusoria are quite harmless and abound in most waters. Some of the infusorians existing in the algal and fungal growth, however, are indicative of sewage, such as *Euplotes patella* and *Oscillatoria*, found in a reserve tank outflow growth in the sea-water circulation, and *Euplotes patella*, *Cryptomonas* and *Carchesium lachmanni*, in the angel-fish tank. It is known, of course, that the circulations of both sea and fresh water are open to pollution by fish excrement in the show-tanks, aeration and storage subsequently causing oxidation to nitrate. The higher temperature of the water in the tropical show-tanks evidently favours the growth of both animal and vegetable microscopic life. This is evidenced in the abundance of micro-organisms present in the growth lining the sides of the angel-fish tank.

The bacteriological results are extremely interesting from the point of view of purification. As already stated, it is practically inevitable that bacteria of the intestinal type should be present in the water, arising from fish-sewage, and the point of interest is their elimination by the purification-methods employed in the Aquarium.

The most striking point in the results cited in Tables III. and IV. is the efficiency of dark storage in the elimination of "blood-heat" bacteria. These are probably introduced into the water with the meat food on which the fish are fed. The water entering the reservoir prior to storage contained on an average 96 organisms per cubic centimetre, capable of growth on agar in 48 hours. After 28 days' storage this number was reduced to 10, and after 42 days to 3—in other words, 97 per cent. of the organisms were eliminated. Taken in conjunction with the physical and chemical advantages resultant upon dark storage (Stowell, *ibid.* 1926, p. 245), it cannot be questioned that dark storage is a most efficient agent of purification.

In the case of the fresh water, the duration of storage is not

more than two days. As a slight multiplication of bacteria always takes place in a stored water before the process of natural elimination predominates, the results show a slight increase in the number of organisms per cubic centimetre after storage. It must be remembered, however, that the oxidative processes effected by aeration reduce the quantity of organic nitrogenous matter present in the water, which forms a suitable medium for the growth of bacteria, hence undue increase in the reservoir is prevented. The counts for the respective show-tanks in the salt and fresh water circulations indicate that lack of prolonged storage in the latter case is responsible for a slight increase in the number of bacteria per cubic centimetre, as compared with the sea-water. The slower rate of filtration in the fresh-water circulation tends to keep down the increase, however. In both salt and fresh water, the value of filtration is apparent.

Turning to the results for the number of bacteria capable of growing on gelatine at 20° C., we find again that the fresh water contains a greater number of organisms per cubic centimetre than the salt water. This may be attributed, again, to the absence of dark storage for prolonged periods. In both circulations the number of liquefying or proteolytic organisms in 1·0 or 0·5 cubic centimetres of the water were too numerous for a count, causing total liquefaction—with 0·05 and 0·02 cubic centimetres, however, a comparison was possible. Thus for the larger quantities (1·0 and 0·5 c.c.) the counts were taken on agar at 20° C. It will be observed that filtration reduces the latter in the sea-water circulation from 900 per c.c. to 260, while storage for 28 days further reduces their number to 150, an additional fourteen days bringing the number to 89. It must be borne in mind that an enclosed body of water such as an aquarium must abound in bacterial life, and the point of absolute number must not be stressed as any cause for alarm, as the vast majority of these organisms are harmless—as, indeed, the absence of epidemic shows. The counts on gelatine indicate a ratio of non-proteolytic to proteolytic bacteria of, roughly, 8 or 10 to 1. Filtration reduces the total number of organisms from 900 to 260, and storage effects a further reduction to 89.

From Table IV. we see that filtration also effects a substantial reduction in the number of bacteria growing on agar at 20° C., the value falling from 2000 per cubic centimetre to 320. The percentage reduction is greater even than in the sea-water circulation, owing to the slower rate of filtration. The values after the unavoidably short period of storage show a slight increase, as would be expected. The ratio of non-proteolytic to proteolytic is again roughly 8 or 10 to 1.

It will be seen from the foregoing results that filtration and storage perform their function as purification-agents in materially reducing the number of bacteria passing from the show-tanks. The fact of their utility—more, their indispensability—has been proved from physical, chemical, and bacteriological points of

view. If any helpful criticism can be submitted, however, on the purification-processes which from the results are seen to be decidedly efficient, it is perhaps from the point of filtration. It is essential that the sea-water be circulated at a fairly rapid rate, as otherwise cloudiness is observed in the show-tanks. The fine sand in the filter-beds settles down in a compact mass, and is very resistant to the rapid passage of water. As a consequence, the surface has to be raked up occasionally, and in so doing the matted mass of zooglœa becomes broken. This film of zooglœa when unbroken provides the chief impediment to the passage of bacteria, which collect in the mass and, though multiplying there, cannot pass the filter. But, as shown by various investigators, when the film is disturbed, immense numbers of bacteria are released and pass *through* the filter. Were it not for the fact that an increase in the filter-area is not available, nor any accommodation for increasing their depth, the authors would be inclined to put forward a tentative suggestion in order to prevent the clogging of the filters. A modification of the method adopted by the Metropolitan Water Board (see Metropolitan Water Board Reports) might be an improvement, and prevent the necessity of periodical raking. A layer of pebbles, covered with coarse sand, might be placed underneath the fine sand at present in use. This would prevent excessive clogging, and the formation of the mass of zooglœa, which is the main advantage of sand-filtration, need not be interfered with. Lack of space, however, prevents this suggestion being carried out at present. The filters, moreover, are quite effective for the removal of débris and reduction of the number of bacteria; and since the water is clear, the mortality low, and absolute freedom from epidemic exists in the Aquarium, any radical change in the present system is really unnecessary.

SUMMARY.

1. The micro-biological conditions existing in the sea- and fresh-water circulations of the Aquarium have been investigated, and the efficiency demonstrated of filtration and storage for the removal of micro-organisms (other than bacteria). By far the largest proportion of the organisms exist in the algal and fungal growths lining the sides and outflows of the show-tanks.

2. The success of the purification methods employed in the Aquarium is also shown by the reduction in the total number of bacteria passing from the show-tanks through the circulation.

3. Bacteriological investigation reveals the fact that dark storage is responsible for the elimination of 66 per cent. of the ordinary bacteria and 97 per cent. of the so-called "blood-heat" organisms and bacteria of the human intestinal type.

19. The External Characters of a Bush-Dog (*Speothos venaticus*) and of a Maned Wolf (*Chrysocyon brachyurus*), exhibited in the Society's Gardens. By R. I. Pocock, F.R.S., F.Z.S.

[Received February 8, 1927: Read April 26, 1927.]

(Text-figures 9-18.)

No two species of wild dogs differ more profoundly in appearance than the Bush-Dog (*Speothos venaticus*) and the Maned Wolf (*Chrysocyon brachyurus*), both of which are confined to South America. Apart from some of the Foxes, the Bush-Dog is the smallest member of the Canidæ, and has a thick massive

Text-figure 9.

The Bush-Dog (*Speothos venaticus*).

head, with small ears and a short powerful muzzle, and a long body supported upon short stumpy legs and provided with a short tail. The Maned Wolf, on the contrary, surpasses an ordinary wolf in stature, and has a fox-like head with a narrow slender muzzle and large ears, and a short body supported upon exceptionally long legs and provided with a long bushy tail. Yet

despite these differences the two agree, as has long been known, in the structure of the cæcum which, instead of being longish and coiled upon itself, as in nearly all the dogs and foxes, is short and uncoiled. The only other dogs which possess a similar cæcum are the so-called crab-eating dogs, of which *Cerdocyon thous* is the type—a group also restricted to South America,—and, curiously enough, the Racoon-Dog (*Nyctereutes*) of China. I verified the structure of the cæcum in the two specimens which form the subject-matter of this paper, and, so far as the external

Text-figure 10.

The Maned Wolf (*Chrysocyon brachyurus*).

characters are concerned, discovered some other unexpected resemblances between them connected with the feet and rhinarium. These and other organs have never previously been adequately described from fresh material.

The most striking external differences between the two species are accompanied by corresponding differences in habit. From the somewhat badger-like build of the Bush-Dog, it is clear that, in the matter of general activity, it is inferior to all the other

species of the family, and does not depend to the same extent upon quickness of pounce or speed of foot for the capture of its prey; and the head has none of the alertness of aspect due to the long erect ears and slender quick-snapping muzzle characteristic of all the smaller species of Canidæ. We know, as a matter of fact, that the Bush-Dog is a forest-species frequenting the banks of rivers and creeks, and picking up any small animals it may come across, and possibly feeding to a great extent upon fresh-water crabs.

The Maned Wolf, on the other hand, has the above-mentioned characteristics of the head—*i. e.*, the large ears and long slender muzzle—more pronounced than in any species of large dog. It frequents, for the most part, pampas-country, overgrown with long grass and low scrub. Nevertheless, it does not appear to me to be built on the lines of a particularly swift runner. Its exceptionally high stature and long legs rather seem to be adapted for giving wide range of vision for the detection of prey and for leaping high in the air over obstacles to keep the quarry in sight when in full pursuit. Those who have seen dogs after rabbits on ground with low cover will appreciate the importance to the pursuer of this method of keeping the pursued in view.

The Head and its Organs.

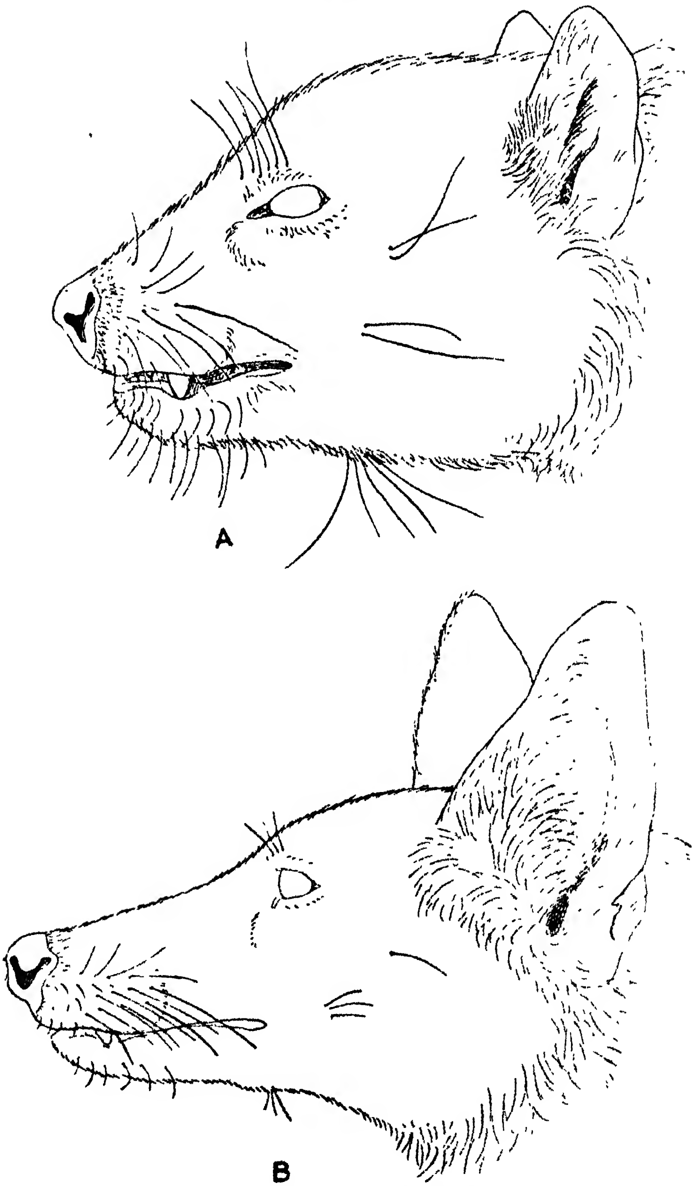
The Facial Vibrissæ.—The facial vibrissæ in *Speothos* are normal in the number of tufts. The mystacials are comparatively few in number, and are sometimes crinkled and all are short—as compared, for example, with those of a Fox—the longest hardly projecting beyond the angle of the mouth. The superciliary tuft is well provided with some half-dozen moderately long bristles. Each of the genal tufts consists of about two bristles, but their tips do not reach back as far as the ear. The submentals are exceedingly well developed numerically and are longer than is usual in the family. The interramal vibrissæ are also numerous and most of them are exceptionally long, as long as any of the vibrissæ on the head. (Text-fig. 11, A, p. 310.)

The vibrissæ in *Chrysocyon* are all relatively much shorter than in *Speothos*, especially those constituting the superciliary, genal, and interramal tufts and the submental series. (Text-fig. 11, B, p. 310.)

The differences in the development of the vibrissæ in these two dogs are obviously correlated with the difference in their predatory habits above referred to.

The *Rhinarium* of *Speothos* is large and areolated. The hairs of the muzzle do not encroach upon its upper side, its posterior border being nearly straight and its anterior border lightly convex, with rounded angles. From the anterior aspect, the upper edge is strongly and evenly convex, the nostrils are widely separated, and the infranarial portion on each side is exceptionally

Text-figure 11.

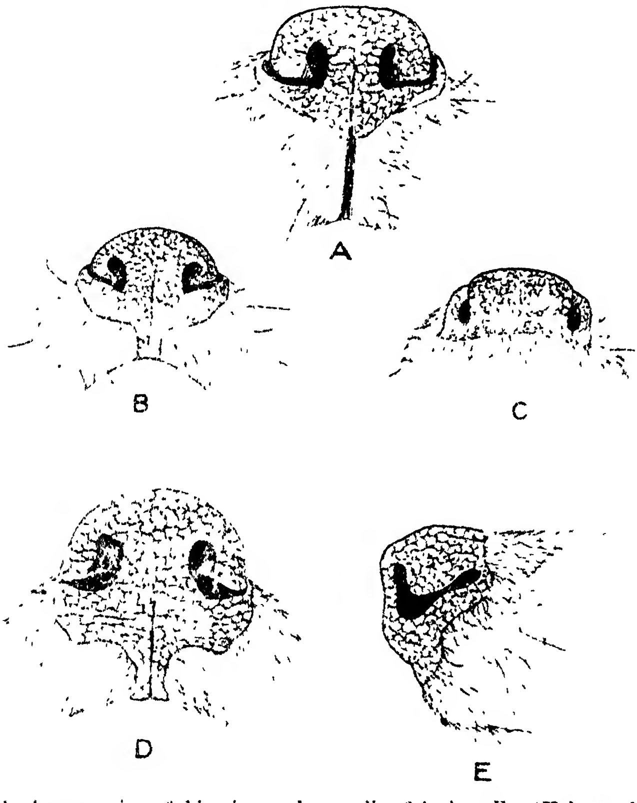


A. Side view of head of *Speothos venaticus*, half natural size.
B. Side view of head of *Chrysocyon brachyurus*, about one-third natural size

deep. The philtrum is short but well defined, and has a median groove which passes up the middle line of the rhinarium about as high as the lower rim of the nostrils. (Text-fig. 12, B, C.)

The rhinarium is remarkable for the great depth of the infra-narial areas, which towards the middle line are as deep as in

Text-figure 12.



A. Anterior view of rhinarium and upper lip of Arabian Fox (*Vulpes vulpes arabica*).
B. The same of *Speothos*.
C. Dorsal view of the same.
D. Anterior view of the same of *Chrysocyon*.
E. Lateral view of the same.

Cerdocyon microtis, and considerably deeper laterally (see Proc. Zool. Soc. 1914, p. 921, text-fig. 5, C, D).

The rhinarium of *Chrysocyon*, viewed from the side, is more convex on the summit and more prominent below the nostrils in front than in *Speothos*. From the anterior aspect it is higher

with regard to its width. The area above the nostrils is more strongly convex and dome-shaped, and the area below the nostrils is even deeper. The philtrum is tolerably similar in the two; but in the specimens described the median groove in *Chrysocyon* scarcely reached to the centre of the infranarial portion, whereas in *Speothos* it extended to the middle of the internarial area. This, however, is probably an inconstant character. (Text-fig. 12, D, E, p. 311.)

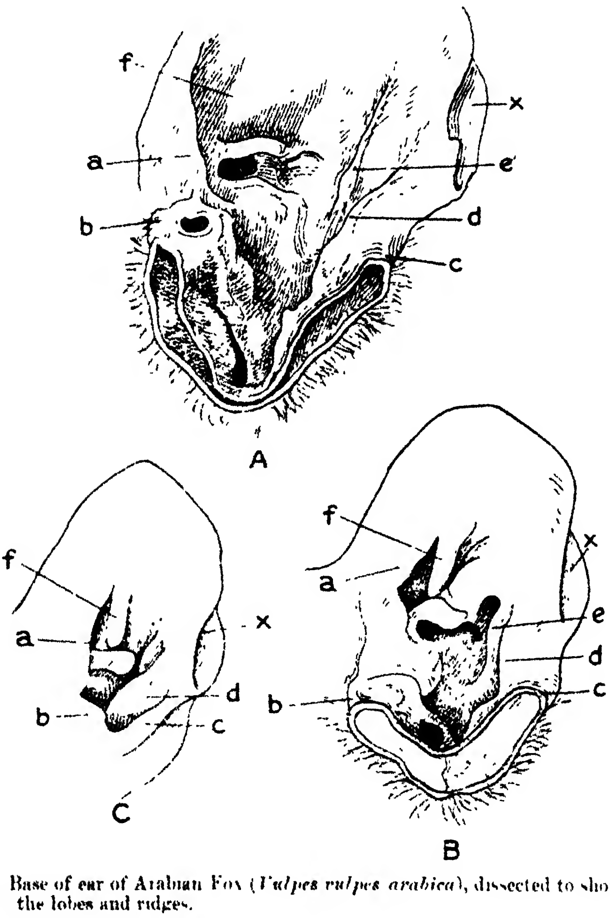
The similarity between these two dogs in the great depth of the infranarial area of the rhinarium is curious. The only other South American dog which shows an approach to this unusual canine feature being *Cerdocyon*, which also, it will be remembered, has a short simple cæcum.

The definite extension of the rhinarium to the edge of the upper lip in both genera is also an unusual feature. In most Canidæ the rhinarium can hardly be described as extending to the edge of the lip. Its median groove is continued as a deep gutter bordered on each side by an area of naked pitted skin, and this gutter can be closed by the approximation of its edges, so that the lip is then divided merely by a median streak. This is shown in the figure of the rhinarium of a Fox (text-fig. 12, A, p. 311).

The *Ear* in *Speothos* is small, its bluntly pointed apex only projecting to a slight extent above the level of the head. The bursa (x) is shallow. Its posterior flap is normal in size and has a convex margin, but its anterior flap is reduced to a low crest of skin with a nearly straight margin, showing no trace of the notch in its lower portion present in other species of Canidæ. The cavity of the ear is bounded in front by a ridge (a), which descends nearly vertically and inferiorly curves backwards beneath the normally thickened supratragus and blends with the flattened area below the supratragus. The anterior margin is completed below by the tragal ridge (b), which is oblique and lightly convex, its edge inferiorly passing into the shallow wide intertragal notch, from which a shallow straight antitragal ridge (c) ascends towards the lower end of the bursa (x). The auditory orifice, which is concealed from view, lies within the tragal ridge. It has a well-defined upper rim, which passes upwards and anteriorly into a well-marked cartilaginous thickening. Inside the inconspicuous antitragal ridge there is a well-developed cartilaginous crest (d), which descends with a sinuously curved edge from a point in front of the lower end of the bursa, to terminate in a point immediately behind the auditory orifice: and inside this ridge and dipping behind its upper end there is another ridge (e), which vanishes on the flat area some little distance below the posterior end of the supratragus. The only other ridge to be noticed is the elongated parallel-sided ridge (f), which descends vertically from the upper portion of the cavity to terminate in a rounded end just above the supratragus. (Text-fig. 13, B, C, p. 313.)

The figures of the ear of an Arabian Fox, inserted for comparison, shows not only that the upper portion of the ear is much larger than in *Speothos*, but that the cavity is much deeper inferiorly. The orifice opens low down in the same position in

Text-figure 13.



A. Base of ear of Arabian Fox (*Vulpes vulpes arabica*), dissected to show the lobes and ridges.

B. The same of *Speothos*.

C. The same undissected, but stripped of hair

The lettering indicates the ridges referred to in the text.

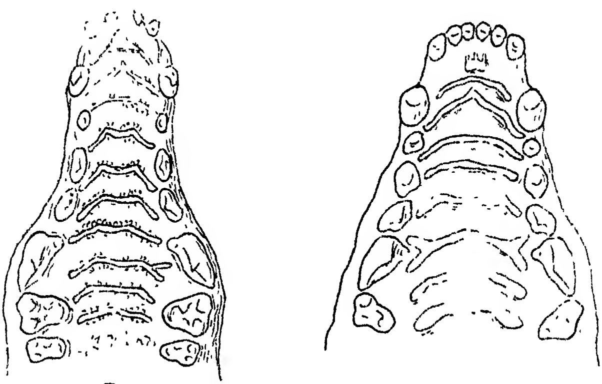
the two; but in the Fox it is insunk at the bottom of a narrow upwardly extending groove. In the Fox, too, there is on the inner surface of the tragal thickening an oval or reniform pit—

found in most Canidæ, but absent in *Speothos*. For the rest, the ridges and thickenings are the same in number and position in the two forms, but differ in structural details as the figures show. So far as my observations extend, the ear of the Fox does not differ in any important characters from that of most genera of Canidæ. (Text-fig. 13, A, p. 313.)

The ear of *Chrysocyon brachyurus* was not examined in detail, but my sketch of the head shows that the bursa is well developed and normal, and exhibits the characteristic notch on its anterior edge. (Text-fig. 11, B, p. 310.)

The palate of *Speothos* has a small median pad behind the incisor teeth and immediately in front of the first ridge, which is slightly curved and lies between the anterior half of the

Text-figure 14.



B A

A. Palate of *Speothos*.
B. The same of Arabian Fox (*Vulpes vulpes arabica*).

canines. The second rises on each side between the canine and the first premolar and is rather strongly angular, its middle point reaching nearly up to the first ridge. The third is lightly curved like the first, and its ends terminate opposite the space between the first and second premolars. The fourth and fifth lie respectively between the second and third premolars, and the sixth between the fourth premolars (carnassials), its ends bifurcating opposite the inner cusps of those teeth. The seventh and eighth are mesially interrupted, the seventh lying in the space between the fourth premolars and the molars, and the eighth between the molars. Thus there are only eight ridges in all. (Text-fig. 14, A.)

The palate of *Chrysocyon brachyurus* was not examined. For comparison with that of *Speothos* I give a figure of the palate of

an Arabian Fox, *Vulpes vulpes arabica.* This has ten ridges with traces of an eleventh between the second molars, teeth which are missing in *Speothos.* (Text-fig. 14, B, p. 314.)

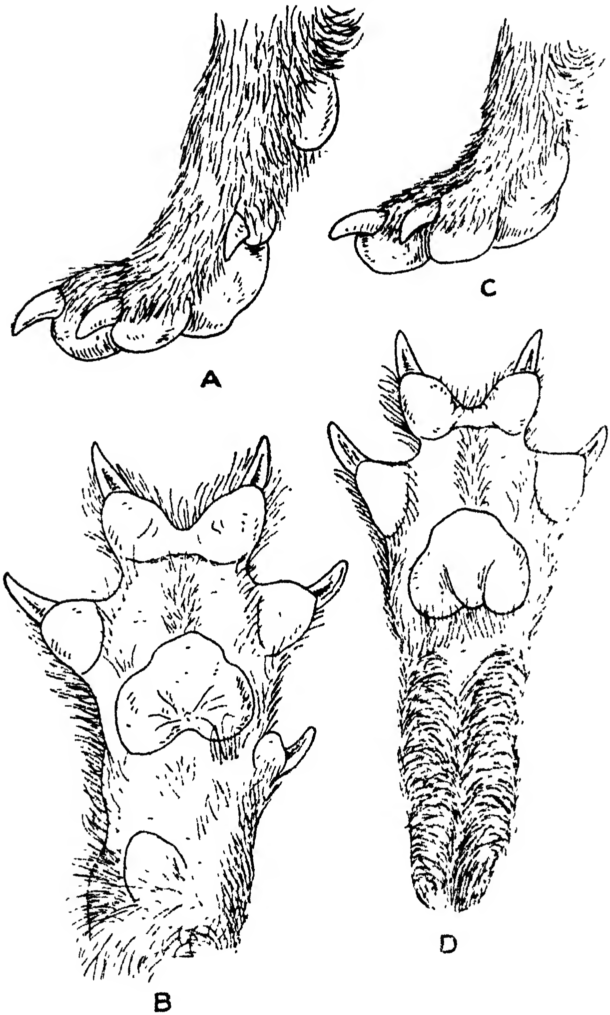
In the present state of our knowledge of the palatal ridges of the Carnivora, which is in its infancy, it is impossible to homologise the ridges in these two animals. It may be that the eight present in *Speothos* are homologous to the first eight in *Vulpes*; but if we compare them with respect to their position regarding the teeth, and assume that *Vulpes* exhibits the more primitive arrangement, it seems that the sixth and probably the eighth of *Vulpes* have been lost in *Speothos.*

The Feet.

In *Speothos* the fore foot is broad and short, the first digit or pollex being set low down close to the proximal edge of the inner lobe of the plantar pad, and the large ovate carpal pad being considerably nearer the plantar pad than in other Canidæ, the distance between them being about equal to the distance between the plantar pad and the pads of the third and fourth digits. All the pads are finely corrugated or coriaceous as in other genera. The digital pads of the third and fourth digits are united at their inner proximal angles by a short area of corrugated naked skin, giving the appearance of fusion of the two pads. The plantar pad is of average size and form and indistinctly three-lobed, but the median lobe is less prominent anteriorly and the posterior margin is less deeply excavated than usual. The area between the plantar and digital pads is to a great extent naked, there being a line of hairs in the middle and a uniserial fringe on each side, with a few scattered hairs near the plantar pad. The area between the plantar pad and carpal pad is similarly naked, showing merely a few scattered hairs in the centre and laterally. The area on the internal or radial side of the carpal pad is also nearly naked, whereas that on the ulnar or external side is tolerably thickly hairy. Just above the carpal pad, the hairs become reversed in direction of growth, turning upwards and inwards. (Text-fig. 15, A, B, p. 316.)

The hind foot is narrower than the fore foot and is also short, the metatarsal area between the heel and the plantar pad being only a little longer than the distance between the proximal margin of the plantar pad and the tips of the digital pads of the third and fourth digits. These pads, like those of the fore foot, are basally united by naked skin, but do not present quite the same appearance of fusion. The plantar pad is broadly cordate, obscurely three-lobed distally, the median lobe being widely rounded; proximally the three lobes are defined by two grooves and the proximal margin is scarcely excavated in the middle line. The area between the plantar and digital pads is for the most part naked, being hairy along the middle line and laterally as in the fore foot. Immediately above the proximal margin of the

Text-figure 15.



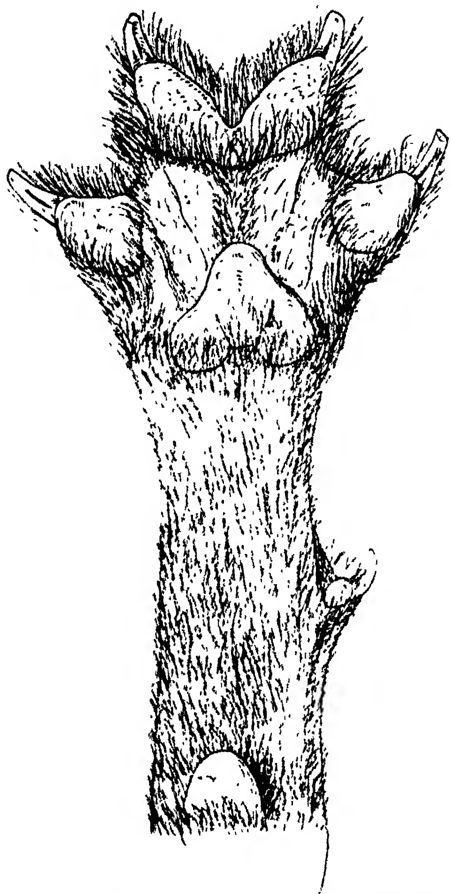
A. Right fore paw of *Speothos* from the inner side.
B. The same from below.
C. Right hind paw of the same from the inner side.
D. The same from below.

plantar pad the hairs of the metatarsal area form a downwardly directed fringe. Above this there is a narrow naked space formed by a change in the direction of the hairs of the rest of

the metatarsal area, which are directed inwards towards the middle line, their tips curving upwards. (Text-figs. 15, C, D, p. 316.)

My figures and description of the feet of this species (Proc. Zool. Soc. 1914, pp. 914–915, fig. 1, A, B) were taken from a

Text-figure 16.

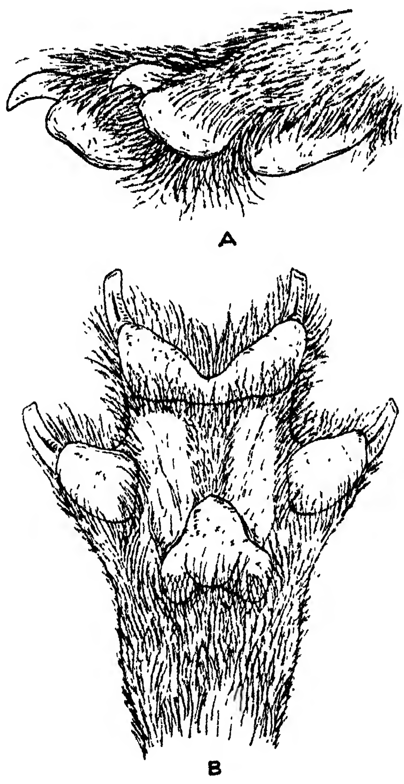


Right fore paw of *Chrysocyon brachyurus* from below.

dried skin, which is preserved in the British Museum. On the evidence supplied by this skin I stated that the feet of *Speothos* differ from those of all the other species of Canidæ in the complete fusion of the proximal ends of the pads of the third and fourth digits. Examination of the fresh specimen

shows, however, that the fusion is apparent rather than real and that it is more accurate to state that the pads in question are united proximally by a narrow interdigital web, the edge of which is greatly thickened and simulates the pads in colour and texture instead of being pallid and smooth as in other Canidæ. The difference, therefore, is not so great as was supposed ; and a

Text-figure 17.

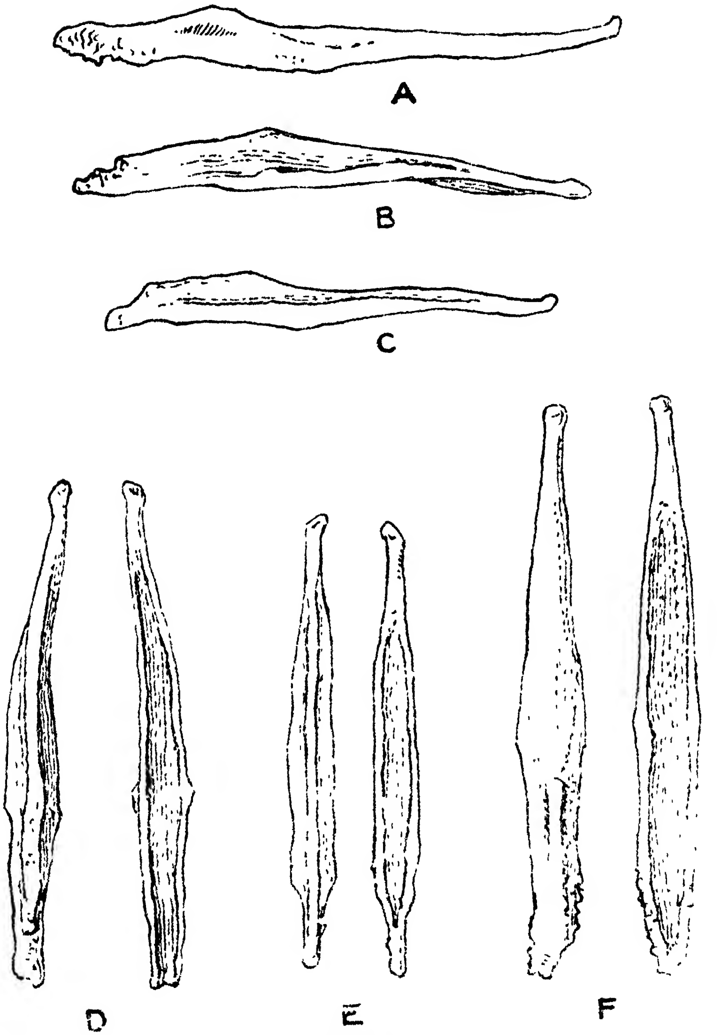


A. Right hind paw of *Chrysocyon brachyurus* from the inner side.
B. The same from below.

foreshadowing of the modification observed in *Speothos* may be seen in *Lycaon*, *Cyon*, and, as I have found since the above-quoted paper was written, in *Canis aureus*, in which the pads of the third and fourth digits are united by a very definite band of hairless integument.

In the skin referred to also the hairs just above the plantar

Text-figure 18.



A. Baculum of *Chrysocyon* from the right side.
B. The same of *Speothos.*
C. The same of *Pseudalopex azarica.*
D. Dorsal and ventral views of baculum of *Speothos.*
E. The same of *Pseudalopex azarica.*
F. The same of *Chrysocyon.*

All natural size. In D, E, F the left-hand figure represents the dorsal and the right the ventral aspect of the bone.

pads on both the fore and the hind foot are directed downwards, not reversed in direction as in the fresh specimen of *Speothos*.

In *Chrysocyon* the fore foot is of great length, longer than that of any species of Canidæ known to me, not excepting the Hunting Dog (*Lycaon*). The pollex is situated just above the middle of the metacarpal area between the plantar and carpal pad, and the length of this area is about four times that of the area between the plantar pad and the pads of the third and fourth digits. These pads are united proximally in the middle line, as in *Speothos*, and I am not acquainted with any other South American species of Canidæ in which this modification occurs. The digital pads are more conical and less rounded than in *Speothos*, and the plantar pad is relatively smaller and differently shaped, the lateral lobes being smaller and the median more prominent. In the matter of hairiness, the feet of the two genera differ considerably. The metacarpal area in *Chrysocyon* is continuously hairy down to the plantar pad, close to which the hairs form a distinct fringe, and similar long fringes are present round the digital pads and normally overlap them. There is a band of hairs between the plantar pad and the pads of the third and fourth digits, but the lateral webs are more scantily hairy. (Text-fig. 16, p. 317.)

The hind foot needs no detailed description, because, apart from being smaller, it resembles the fore foot very closely in the size and shape of its pads and the hairiness of the area round them. (Text-fig. 17, A, B, p. 318.)

The Baculum.

The baculum of *Speothos* is relatively large for the small size of the species. On its upper side it is provided with a strong ridge or crest, which rises into a very obtuse angle in the proximal half of the bone and gradually dies away distally, although defined on the right side by a groove extending almost to the tip of the bone. The inferior groove is wide and reaches nearly to the distal end. In the specimen figured (text-fig. 18, B, D, p. 319), the bone is slightly twisted over to the right, and the crest inclines to the left side; but the baculum of the Bush-Dog that died in the Gardens was straight and sub-symmetrical distally.

The baculum of *Chrysocyon brachyurus* is only a little larger than that of *Speothos*, despite the great difference in size between the two species. Its dorsal crest is short and practically restricted to the middle of the proximal half. Distally to it the upper side of the bone is tolerably evenly curved from side to side. The groove beneath is wide, but does not extend so far towards the tip as in *Speothos*. (Text-fig. 18, A, F, p. 319.)

For comparison with the bacula of these two species, I have figured the baculum of an example of *Pseudalopex azarica* from

Mar del Plata in the Argentine. This bone is more compressed at its proximal end than in the others. It is a smaller bone than that of *Speothos*, but as in that species the dorsal crest is defined nearly up to the end of the bone; but the shape of the bone is more like that of *Chrysocyon*, and the wide groove on its lower side only extends over three-quarters of the length of the bone. (Text-fig. 18, C, E, p. 319.)

20. Note on Acari, mainly belonging to the Genus *Spinturnix* von Heyden. By STANLEY HIRST, F.Z.S.

(Submitted for publication by permission of the Trustees of the British Museum.)

[Received January 18, 1927: Read April 26, 1927.]

(Text-figures 1–13.)

Family GAMASIDÆ.

SPINTURNIX EURYALIS G. Can. (Text-figs. 1 & 2.)

Pteroptus euryalis G. Can. in Acarof. Ital. p. 119, 1885.
Pteroptus euryalis Berlese in Acari, etc. in Ital. repert. Fasc. 54, no. 3, 1889.

♀. The little *jugular plate* well-developed, being strongly chitinized and much wider than long. *Sternal plate* shaped as shown in text-fig. 1; anteriorly it is rather blunt, its posterior margin slightly concave; surface of this plate practically smooth, but there may be a few indistinct scale-like markings which are not reticulate however, only the posterior portion being visible; three pairs of long hairs are present on this plate.

Genito-ventral plate shaped as figured and marked with several curved transverse lines. Hairs on *venter* numerous and rather spiniform, especially the posterior ones. Hairs on *anal plate* quite short and spiniform. *Capitulum* dorsally with a stout little median process or tooth. Hairs on *legs* mostly not very long, but there are two long dorsal hairs on the femora of the first pair of legs.

♂. *Jugular plate* apparently smaller than in the female and less rectangular. *Ventral plate* shaped as shown in text-fig. 2; it is smooth and devoid of markings except four minute punctations; there are four pairs of hairs on this plate, the first pair being long. *Peritremal tube* short, not reaching the venter. Hairs on posterior part of *venter* numerous and not very long.

Measurements:— Length of body (not including capitulum) of ♀ ·54 mm. Length of ♂ ·40 mm.

Hosts. Rhinolophus euryale; Grotto of Pietralbello, Corsica (S. Hirst). *Rhinolophus ferrum-equinum*; Cheddar Caves, ex N. C. Rothschild's Coll.

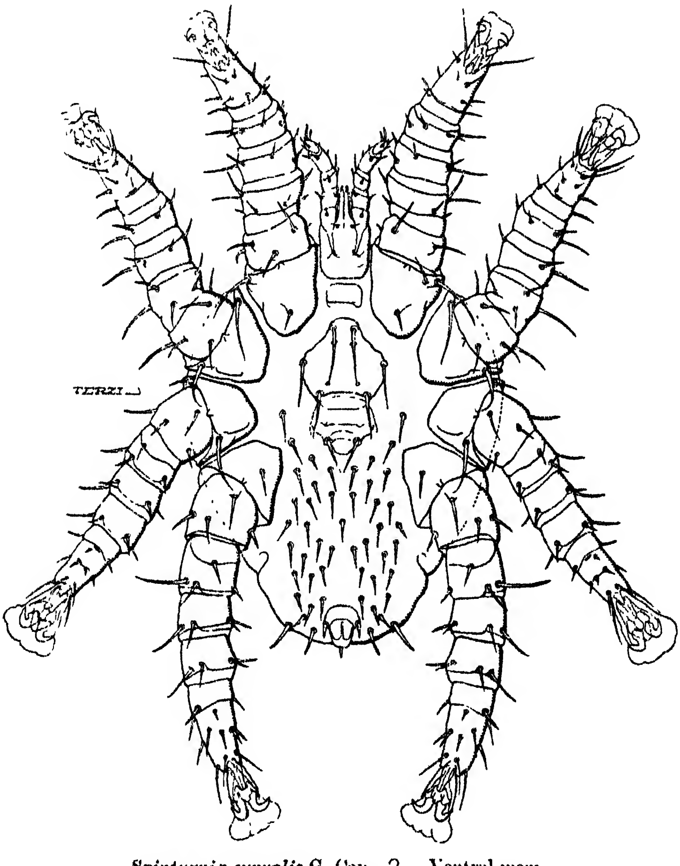
SPINTURNIX VESPERTILIONIS L. (Text-figs. 3–5 *a*.)

Pediculus vespertilionis L. Syst. Nat. 10th edit. vol. i. p. 611, 1758.

♀. Little *jugular plate* represented by a very minute spot of

chitin. *Sternal plate* shaped as shown in text-fig. 3, its surface being marked by a distinct reticulate pattern, the meshes of which are larger than in *S. acuminatus* Koch ; the three pairs of hairs on this plate are short ; two pairs of punctations are also present on it. *Genito-ventral plate* very small and narrow, being pointed posteriorly. *Hairs* on posterior part of *venter* numerous

Text-figure 1.



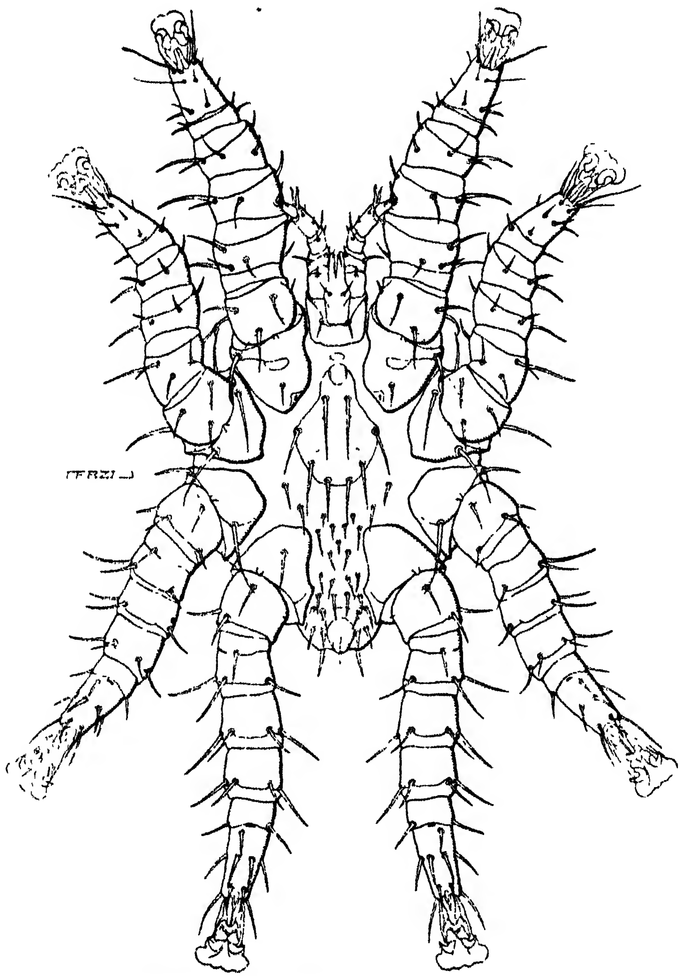
Spinturnix euryalis G. Can., ♀. Ventral view.

but short. A group of comparatively long hairs occurs at the posterior end of the body. *Hypostome* short. *Palpi* fairly elongated. *Coxæ* of *legs* without distinct spurs.

♂. *Jugular plate* small and narrow, but larger than in the female sex. Ventrally the *peritreme* is only continued between the coxæ by a short and narrow strip of chitin instead of the wide

strip present in *P. psi* (see text-fig. 5 *a*). Hairs on posterior part of *venter* rather numerous and sometimes irregular in distribution. *Palpi* elongated as in the female.

Text-figure 2.



Spinturnix euryalis G. Can., ♂. Ventral view.

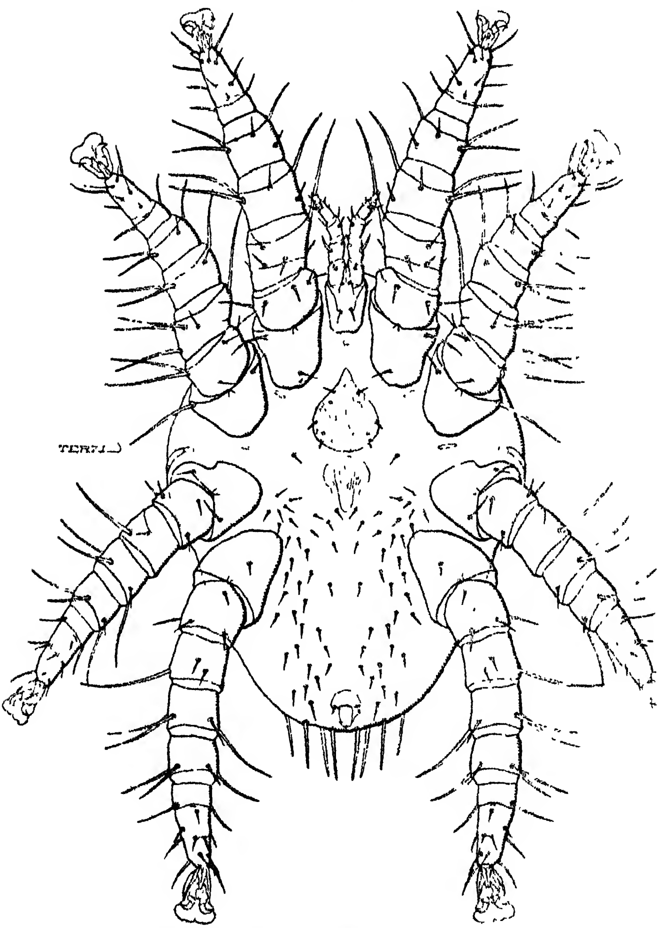
Length of body (not including capitulum), ♀ 1·2–1·43 mm., ♂ 1–1·05 mm.

Hosts and localities.

On *Myotis myotis*; Bergamo, Italy, 1. vii. 11, coll. A. Ghidini.

On the same host; Mazaghan, Morocco, 1. vii. 10 (Riggenbach).

Text-figure 3.

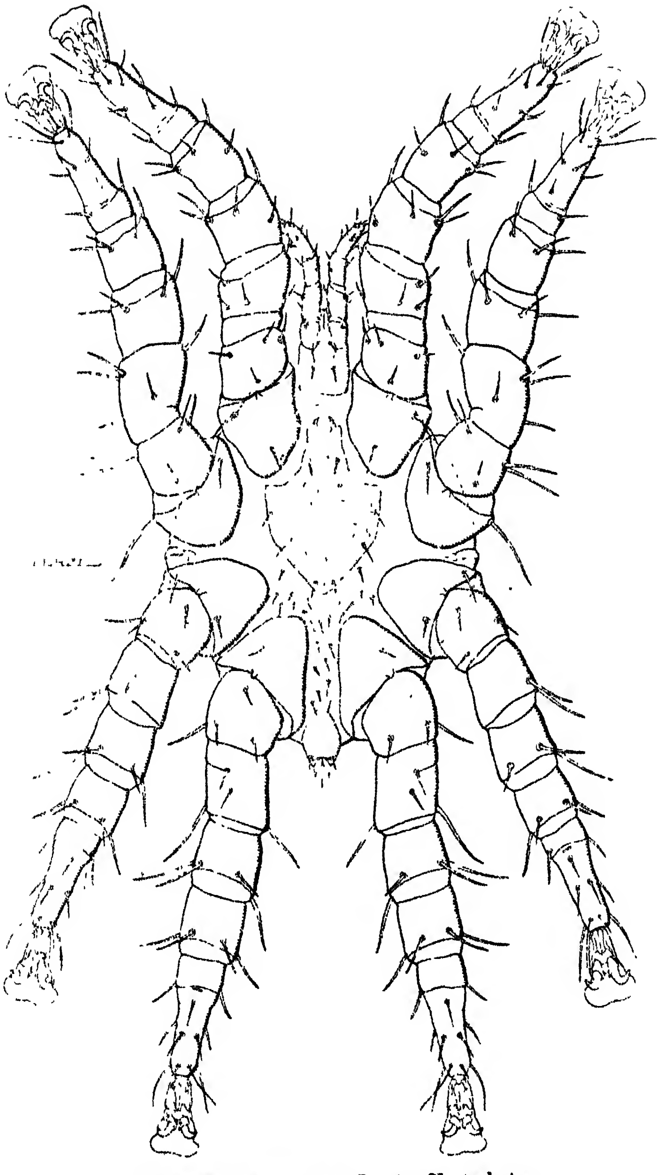


Spinturnix vespertilionis L., ♀. Ventral view.

On *Myotis capaccini*; Moldova, South Hungary, 1. v. 10 (L. Dionyssius).

On *Myotis daubentoni*; Christchurch, Hants, 20. ix. 1909 (A. Whitaker).

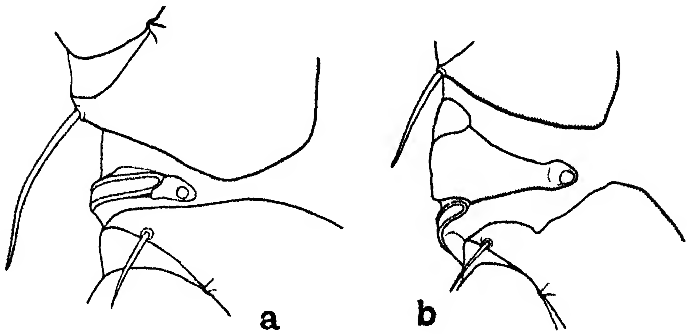
Text-figure 4.



Spinturnix vespertilionis L., ♂. Ventral view.

From the same host at Teddington, Middlesex (A. H. Bishop).
On *Rhinolophus ferrum-equinum*; Novi, Croatia, 1910 (L. Dobeatch).
On *Plecotus auritus*; Zengy, Croatia.

Text-figure 5.



a. Ventral end of peritremal tube and pore of *Spinturnix vespertilionis*, ♂. *b*. The same of *S. psi*, ♂.

With the exception of the specimens from Teddington, all this material was presented to the British Museum by N. C. Rothschild.

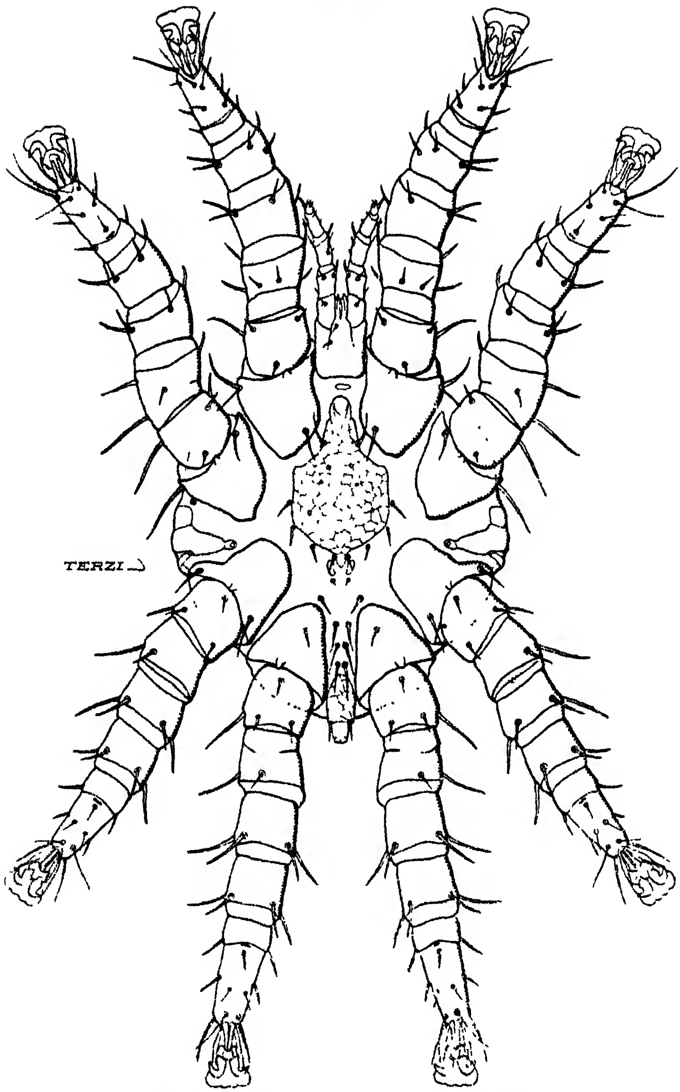
Note.—Linnæus gives *Vespertilio murinus* as the host of this mite. Presumably he meant the species of bat now called *Myotis myotis*. *Vespertilio murinus* for a long time was a "composite" name used for several species of bats now known to be quite distinct species, and is still valid for a rare Swedish bat.

Spinturnix psi Kolenati. (Text-figs. 5 *b* & 6.)

♀. *Size* rather small. *Jugular plate* well developed and shaped rather like a jar, the anterior end being much narrower than the rest. *Sternal plate* shaped very like that of *S. vespertilionis*, but apparently much more weakly chitinized; it is furnished with reticulate markings and two pairs of punctations. Anterior pair of hairs usually on the plate itself, the second pair placed close to it, whilst the third pair is either on the margin or close beside it. *Hairs* on *venter* short, very fine and much fewer than in *S. vespertilionis*. *Palpi* elongate.

♂. *Sternal plate* shaped very like that of the male of *S. vespertilionis* L., but its extreme posterior end narrowed and pointed; markings on its surface very similar but less distinct. There are five pairs of hairs, but several of them although quite close to the sternal plate are not actually on it. *Anal plate* apparently longer than that of *S. vespertilionis*. A fairly wide *chitinous*

Text-figure 6.



Spinturnix psi Kolenati, ♂. Ventral view.

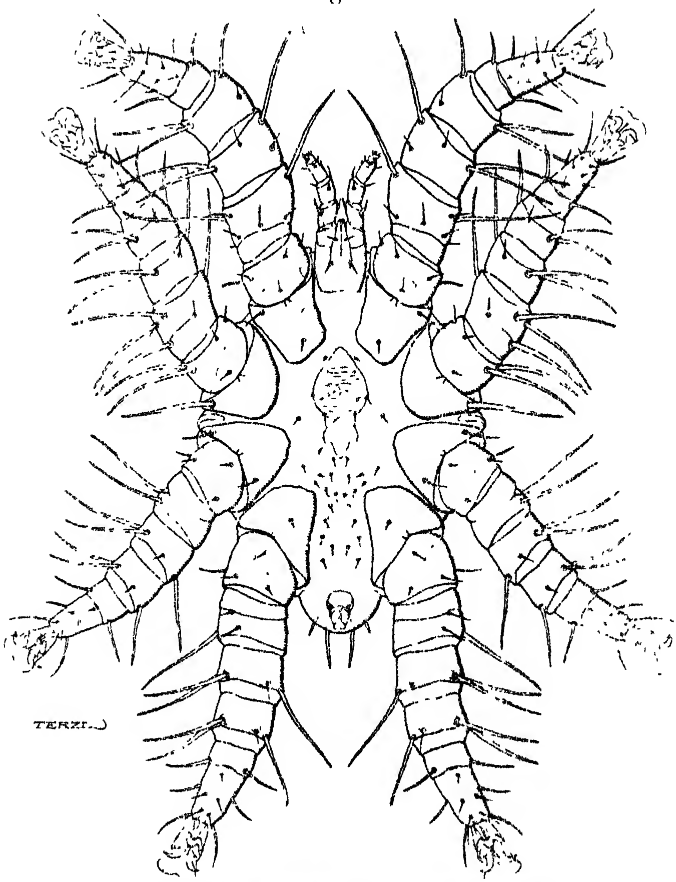
strip bearing the *stigmal pore* extends some distance on to the venter (between the second and third coxæ), the end of the *peritremal tube* being thus removed a little distance from the pore itself. There are only a few pairs of *hairs* between the last pair of coxæ.

Length of body (not including capitulum), ♀ 1·05 mm., ♂ ·85 mm.

Hosts. Kolenati's specimens deposited in the British Museum Collection are from *Miniopterus schreibersi* taken in Serbia. There are also examples collected by the author in March 1922 at Ajaccio either from *M. schreibersi* or else from *Myotis capaccini* ? Also specimens of both sexes from *Rhinolophus ferrum-equinum*, Montgaillard, Hautes Pyrénées (Dollfus Coll.).

NOTE.—The female has been described from the examples taken on *Rhinolophus ferrum-equinum*.

Text-figure 7.



Spinturnix plecotinus Koch, ♀. Ventral view.

SPINTURNIX PLECOTINUS Koch. (Text-fig. 7.)

Pteroptus plecotinus Koch, in Panzer's Faun. Insect. german. 1836, No. 167. 24. Also in Koch's Dtschl. Crust. Myr. u. Arach., H. 23, No. 24.

Pteroptus transversus Kolenati, Parasit. Chiropt. p. 27, 1857.

Spinturnix plecoti Oudmns.? Tijdschr. Ned. Dierk. Ver. (2) viii. p. 31, pl. iii. figs. 49 & 50, 1904.

♀. *Jugular plate* apparently obsolete. *Sternal plate* smaller than in *S. vespertilionis* and faintly rugulose, having very fine mostly transverse wrinkles on its surface instead of the reticulation or scale-like markings of *S. vespertilionis* etc. Two pairs of hairs are present on the sternal plate and another pair placed quite close to the anterior pointed end. The usual two pairs of punctations are also present on it. Hairs on *venter* numerous. Hairs at posterior end of body few in number. *Palpi* fairly elongated. Coxæ and some of the other segments of the *legs* with the surface faintly regulose in the same way as the sternal plate. Tooth on base of *claw* well developed. There is a somewhat flattened dorsal hair distally on tarsi 2-4.

Length of body, ♀ ·90–·97 mm.

Host. Plecotus auritus; Stainborough, Barnsley.

NOTE.—We have also some quite typical specimens of *S. vespertilionis* from the same host from Zengy, Croatia.

SPINTURNIX ACUMINATUS Koch. (Text-figs. 8 & 9.)

Pteroptus acuminatus Koch. in Panzer's Faun. Insect. german. 1836, No. 137. 21 (also No. 21, Heft 4, in Koch's Dtschl. Crust. Myr. etc. (dated a year earlier), but I have not been able to consult this work).

Pteroptus abominabilis Koch, in Panzer's No. 137. 22 (Heft 4, No. 22, in Koch's Dtschl. Crust. Myr. etc.). *Pteroptus arcuatus* Kolenati. Parasit. Chiropt. p. 26. 1857. *Spinturnix carnifex* Koch, Oudemans, Tijdschr. Ned. Dierk. Ver. viii. p. 33, pl. iv. figs. 51 & 52, 1904. *S. noctulae* Oudmns. Ber. Ned. Ent. Deel iii. p. 68. 1910.

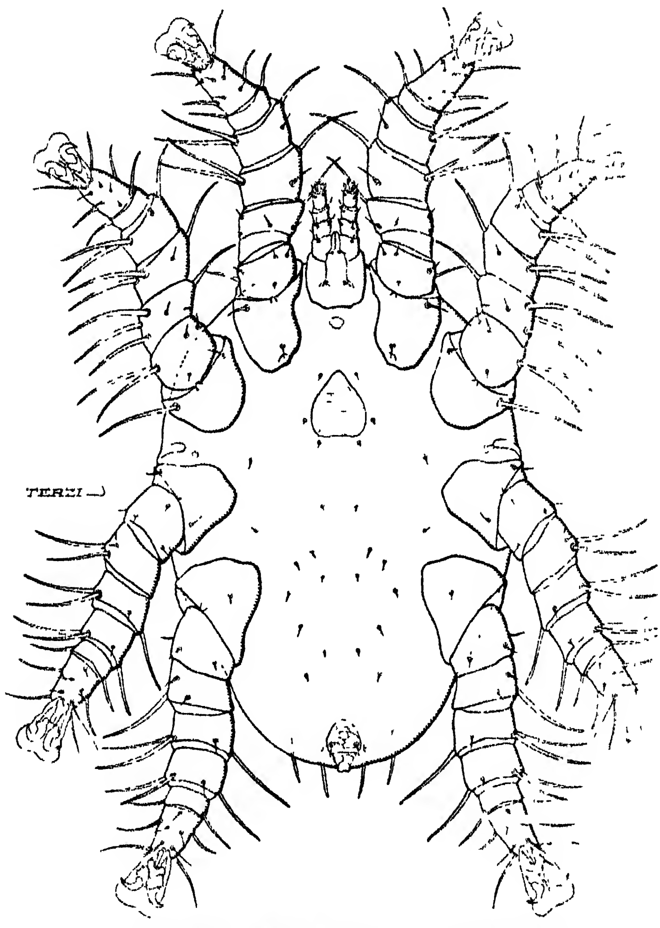
♀. *Sternal plate* much smaller than that of *S. vespertilionis*, the reticulate markings on it similar but fainter, being quite unlike those present on this plate in *S. transversus*: the three pairs of hairs usually present on it are placed on the softer integument close to it. *Hairs* on *venter* much fewer than in *S. vespertilionis*, being very short and fine. *Palp* shorter than in that species.

♂. *Jugular plate* very like that of the male of *S. vespertilionis*, being very small, narrow, and elongated transversely. *Sternal plate* smaller than that of *S. vespertilionis* and the shape different; scale-like markings on it much smaller, more numerous, and less distinct; the three pairs of hairs on this plate very short. *Hairs* on *venter* short and fine, being less numerous than in *S. vespertilionis*, and only two pairs of hairs are present on the posterior part of the strip of integument between the coxæ of the last pair of legs. The *chitinous prolongation* of the *peritremal* tube is more like that of *S. vespertilionis* than that of *S. psi*. *Palpi* much less elongated than in *S. vespertilionis*.

Length of body, ♀ 1·2 mm., ♂ ·80–·88 mm.

Hosts and localities. Both Koch and Kolenati give the Noctule Bat as host. In the British Museum Collection there are males and a nymph labelled *carnifex* and *arcuatus* received from

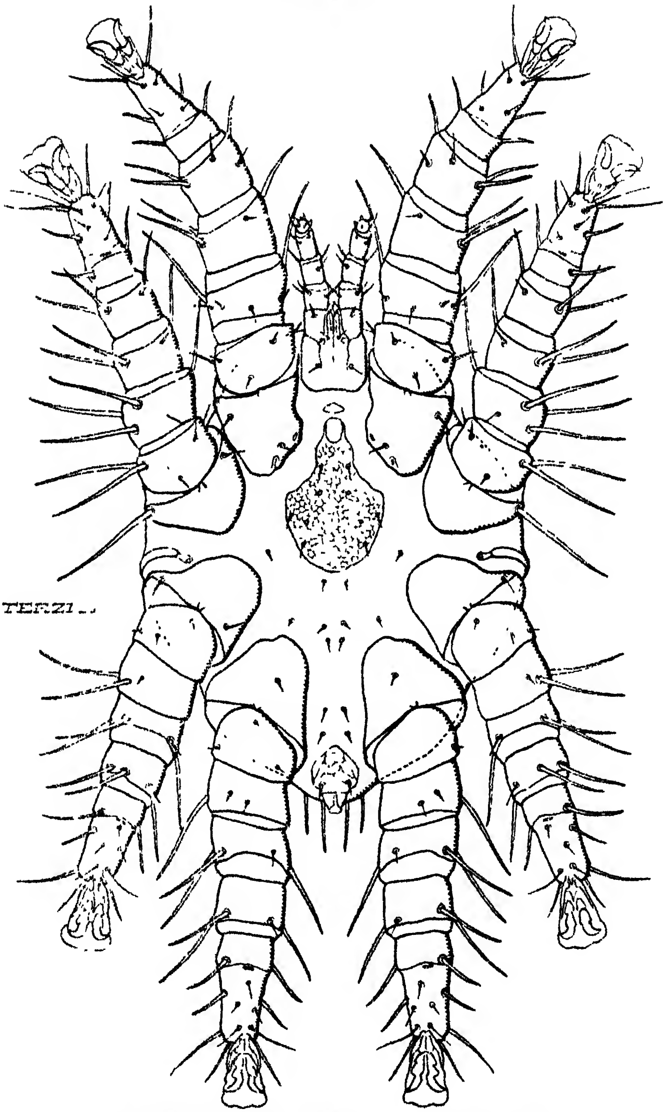
Text-figure 8.



Spinturnix acuminatus Koch, ♀. Ventral view.

Kolenati; also males from Noctule Bat (*Nyctalis noctula*), Bengeo Old Vicarage, Herts (H. Swan), and specimens of both sexes from the Pipistrel Bat (*Pipistrellus pipistrellus*), Rochester (Dr. G. A. K. Marshall).

Text-figure 9.



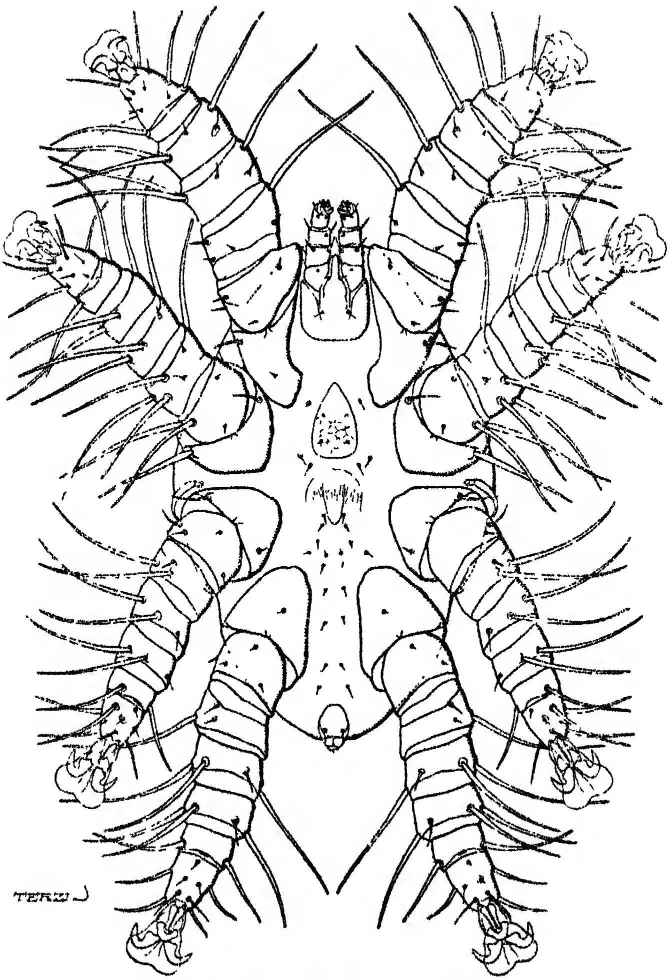
Spinturnix acuminatus Koch, ♂. Ventral view.

Spinturnix abyssinicus, sp. n. (Text-figs. 10 & 11.)

♀. *Sternal plate* apparently a little longer and narrower than is the case in *S. arcuatus* and the reticulate markings faint.

Hairs on *venter* fairly numerous and distributed as shown in figure. *Hypostome* quite short. *Palp* also short as in *S. acuminatus* Koch. Conical tooth at base of *claws* of *legs* large.

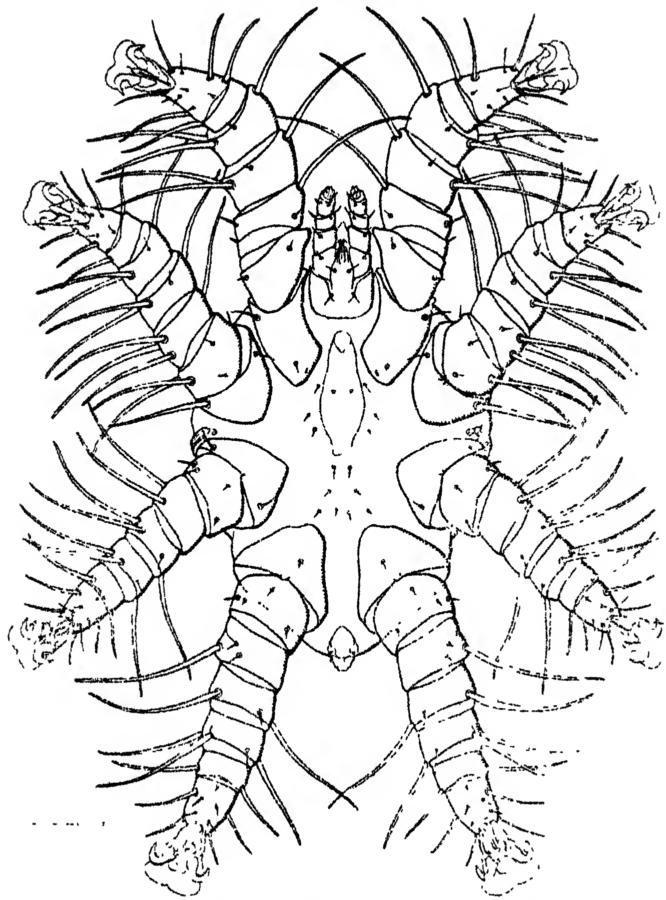
Text-figure 10.



Spinturnix abyssinicus, sp. n., ♀. Ventral view.

♂. *Sternal plate* long and narrow, the reticulation faint (especially in specimens which have been treated with caustic potash). Strip of integument between fourth coxæ without any hairs.

Text-figure 11.



Spinturnix abyssinicus, sp. n., ♂. Ventral view.

Length of body, ♂ 1·02-1·1 mm.

Host and locality. Several specimens on bats, Addis-Abeba, Abyssinia (Janasch & Goetz), ex N. C. Rothschild's Coll.

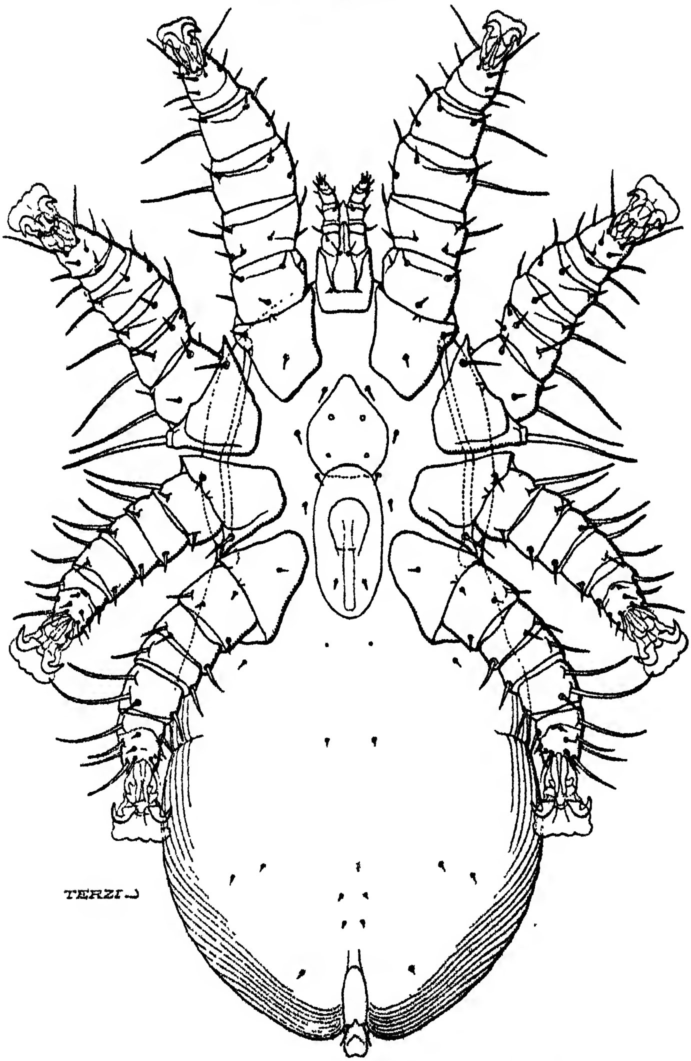
Periglischrus meridensis, sp. n. (Text-fig. 12.)

Tijdschr. Ned. Ent. 1902, vol. xlv. p. 135, pl. 11. figs. 20-27. Also earlier reference (brief diagnosis) in Entomologische Berichten, p. 38; 1, vi. 1902.

♀. *Body* shaped as shown in text-fig. 12, cephalothorax much narrower than abdomen, posterior end of the latter flattened dorso-ventrally, its hinder margin being thin and striated; *anal region*

curiously modified and furnished with a pair of hairs. *Dorsal shields* coalesced and shaped as figured by Oudemans for his

Text-figure 12.



Periglischrus meridensis, sp. n., ♀. Ventral view.

P. jheringi; unfortunately the hairs have become detached in our specimens. *Sternal plate* very like that of *Spinturnix vespertilionis* in shape, but without any trace of reticulate or scale-like

markings ; there are no hairs on it, but it has two pairs of distinct punctations. Three pairs of hairs are situated on the softer integument close to the sternal plate, three on each side of it. *Genito-ventral plate* apparently fairly wide, but delicately chitinized and difficult to see except in the middle line, where there is a fairly long but very narrow strip or line of chitin. *Hairs* on *venter* very short and few in number. *Hypostome* short and slender. *Palp* short. Second *coxa* with both distal angles rather strongly produced, the posterior one bearing a seta. The same angles of the third coxa are also somewhat produced, but form a kind of edge or lobe.

Length of body of ♀'s 1·15 mm.

Host and locality. Specimens found on *Artibeus jamaicensis*; Merida, Venezuela, ex N. C. Rothschild's Coll.

Family ANYSTIDÆ.

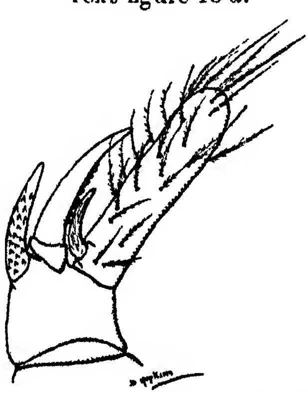
ANANDIA, gen. n.

Dorsum with a fairly large *dorsal scutum* anteriorly. A pair of lateral eyes on each side. Tarsi of legs with many false articulations and three claws, the lateral claws having stout combs on each side as in the Teneriffiolidæ.

ANANDIA ALTICOLA, sp. n. (Text-figs. 13 *a*, *b*.)

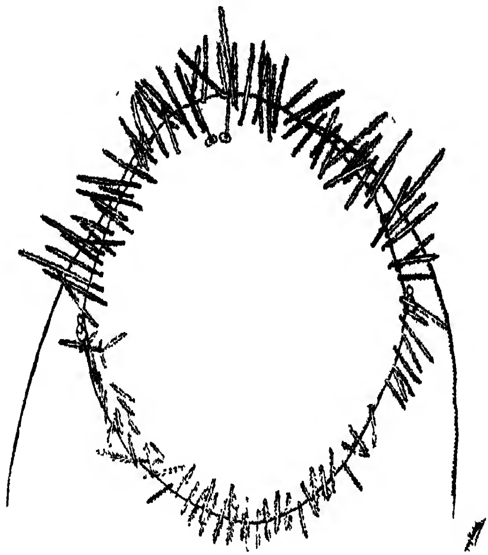
♀. *Body* much longer than wide. *Dorsum* with very numerous setæ varying in length according to their position, the posterior ones being shorter. These setæ are furnished with numerous fine accessory spinules, the latter usually not projecting, but closely applied to the seta. *Dorsal scutum* fairly large, being

Text-figure 13 *a*.



Anandia alticola, gen. & sp. n. Palp

Text-figure 13 *b*.



Anandia alticola, gen. & sp. n. Dorsal scutum.

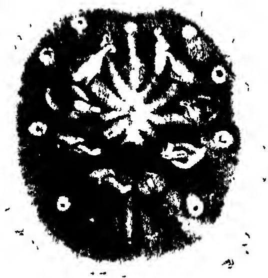
shaped as shown in text-fig. 13 *b*; it is devoid of setæ except on or near the margins; anteriorly not far from the margin there is a pair of pseudostigmal hairs more slender than the rest, but still with accessory spinules and arising from distinct circular sockets. *Eyes* small and inconspicuous, but the posterior one much larger than the anterior. *Palpi* with dense setæ dorsally; penultimate segment of palp with two strong spurs, the distal one being larger and furnished with a double row or comb of denticles; tarsus of palp rather elongated and with a claw-like basal spur (text-fig. 13 *a*). *Legs* fairly long, especially the posterior pairs. Proximal segment including patella densely furnished with setæ; penultimate segment with rather long ventral setæ. *Coxæ* all placed close together and furnished with numerous setæ.

Length of body 1·90–2·1 mm., its width about 1·1 mm.

Hab. Upper Rombok, Mount Everest, 16,500 ft.

1

4



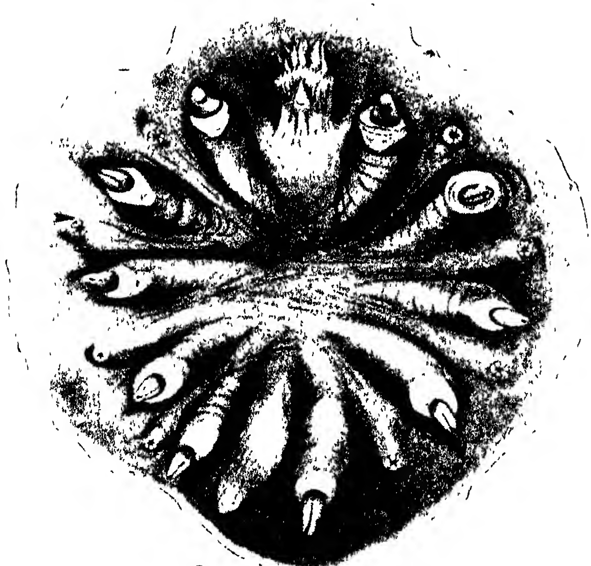
3

2.

John Bale Sons & Danielsson L^td

1-3 MYZOSTOMA POLYCYCLUS, sp n
4 MYZOSTOMA STOCHŒIDES, sp n.

1.



2.

John Bale Sons & Danielsson, Ltd

MYZOSTOMA INSIGNE, sp. n.

21. Report on the Myzostomida collected by Mr. F. A. Potts in Torres Strait, together with a Description of a Species obtained by Professor J. Stanley Gardiner from the Maldives. By Daphne Atkins, B.Sc. (from the Pilcher Research Laboratory, Bedford College for Women).*

[Received November 18, 1926: Read March 22, 1927.]

(Plates I.–II.†; Text-figures 1–15.)

Contents.

The Myzostomida described in the following report were, with one exception, collected by Mr. F. A. Potts from Crinoids obtained at Murray Island at the north end of the Great Barrier Reef of Australia, and Badu, one of the western islands of Torres Strait, during the latter part of 1913. The collection was sent to Prof. C. L. Boulenger, who very kindly handed it over to me for examination while I was working under his direction in the Pilcher Research Laboratory at Bedford College in 1923.

The material consisted of ten tubes containing about 65 specimens, all of which proved to belong to species so far undescribed. Whilst the majority of the specimens were in an excellent condition, a few had unfortunately deteriorated so as to be unsuitable for description; altogether six new species were recognised.

The collection is especially interesting because it was accompanied by notes made by Mr. Potts on the colours of the living animals, and previous records of this description are all too few. Some of the specimens were extremely beautiful and many had very striking colour-patterns, in a few cases retained in the preserved state.

The Myzostomida of this collection belong mainly to two types. In one the body is circular and thin, the more delicate forms being almost transparent, while the marginal cirri are well developed, numbering ten pairs or more. In this type the colour-pattern takes the form of rings, either broken or complete. A striking form belonging to this type had a very pronounced pattern of alternating dark and unpigmented rings; it was found

* Communicated by Prof. C. L. Boulenger, M.A., D.Sc., F.Z.S.

† For explanation of the Plates see p. 357.

on the dark green or black varieties of *Comanthus annulatus*, but though so conspicuous when seen apart from its host, when in its natural habitat was comparatively inconspicuous, the unpigmented rings being transparent.

In the second type the body is stout and thick, and the cirri are inconspicuous or absent. In this type the dorsum, although sometimes smooth, is frequently ornamented with radiating ridges of a lighter colour than the rest of the body, the ridges occasionally being thrown further into relief by encircling lines of dark pigment either black or purple; such forms were found on Crinoids of a colour closely approaching that of the general ground-colour of the Myzostomids. In the two forms in which sculpturing is absent the dorsum was covered with a dark pigment, in one case relieved by a white line down the middle. These were found on dark Crinoids.

I have included in this report the description of a new species of *Myzostoma* collected by Prof. J. S. Gardiner from Crinoids of the Hulula Malé Atoll, in the Maldives. These were handed over to me by Prof. Boulenger together with Mr. Potts's collection.

The descriptions in this report are based on external features only. Sections were not cut of the material as the specimens belong to the more normal types of the genus, and especially as there were only a few individuals of the more important species, and the results likely to be obtained did not seem to justify their destruction by section-cutting.

I should like to express my thanks to Prof. Boulenger for submitting to me for examination such interesting and valuable material, and also for help given throughout.

MYZOSTOMA POLYCYCLUS, sp. n. (Pl. I. figs. 1–3.)

Twenty-two specimens of this extremely handsome and striking Myzostomid occur in Mr. Potts's collection; nineteen were obtained from *Comanthus annulatus* at Murray Island, the remainder being collected at Badu.

The body varies in diameter from 1 to 4·8 mm., it is approximately circular, flat and thin, increasing only slightly in thickness towards the centre. Where the quantity of pigment is not great the body is transparent from the parapodial bases to the margin, the smaller specimens being extremely membranous.

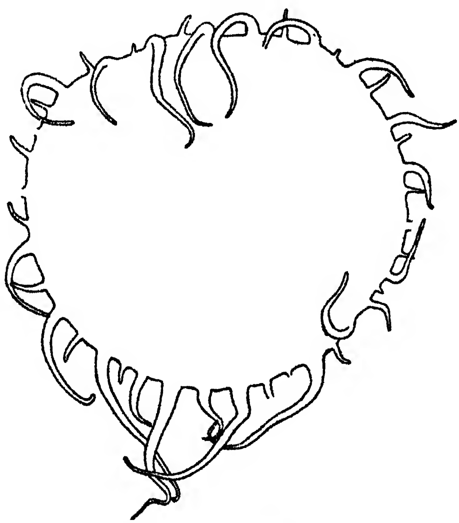
The dorsal surface is ornamented with concentric dark and unpigmented rings; these vary in width in different individuals, and the contrast between them is much more marked in some specimens than in others. The two worms figured represent extremes in the development of the rings (Pl. I. figs. 1, 2), practically every intermediate form occurring in the series; two specimens, moreover, were uniformly pale in colour with the pattern only just distinguishable. As a general rule in the young forms the pigmentation is more diffuse and the rings less

distinct than in the adults. According to a sketch by Mr. Potts, the living Myzostomid possessed also a definite dark streak running longitudinally down the middle of the dorsum; this has almost completely disappeared in the preserved specimens.

The ventral surface of the body is uniformly pigmented except in the marginal zone, which corresponds to the outer light ring of the dorsal side; in the majority of specimens the suckers, parapodia, male papillæ, and pharynx, are unpigmented and show up conspicuously against the dark background (Pl. I. fig. 3).

In referring to the colour-pattern of the living worm and its relation to that of the host, Mr. Potts remarks: "the alternate

Text-figure 1.



Myzostoma polycyclus, sp. n.
Sketch to show the arrangement of the cirri in a small specimen 1·1 mm. long and 1·2 mm. broad.

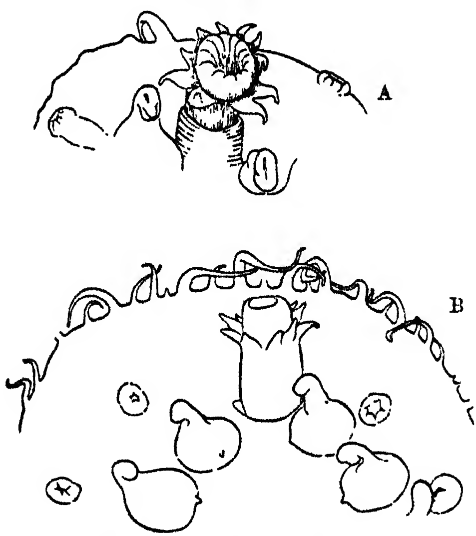
black and non-pigmented rings are in vivid contrast, but the Myzostomid is thin and the non-pigmented parts are so transparent as to be inconspicuous against the dark ground of the host. This species seems to occur only on the darker Crinoids" (6).

In the larger individuals the margin bears numerous slender cirri, apparently indefinite in number and arrangement, those on the lateral margins, however, being slightly shorter than those at the anterior and posterior ends. In the smaller specimens, where the cirri are less numerous and comparatively longer than in the adults, some sort of arrangement can be made out; there appears in these to be a posterior median cirrus and ten pairs

of long primary cirri between which nine or more pairs of shorter secondary cirri are developed (text-fig. 1); the latter grow and are added to as the worm increases in size, until finally all traces of the division into primary and secondary cirri disappear.

The parapodia are well developed, their bases being connected with the central muscular mass by distinct radial ridges. The terminal portions are slender although the actual tips are enlarged. The thick basal portion of each parapodium bears a minute unpigmented cirrus on its under surface, a character which has so far only been described in four other species, *M. cirripedium*

Text-figure 2.



Myzostoma polycyclus, sp. n.

Sketches of extended pharynx with subterminal circlet of small tentacles. A × ca. 53; B × ca. 18.

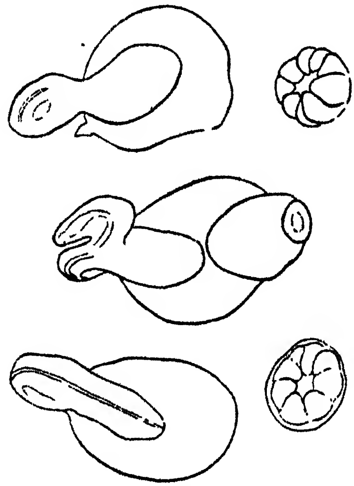
v. Graff (4), *M. circinatum* Wheeler (8), *M. metacrini* McClendon (5), and *M. vincentinum* v. Reichensperger (7). McClendon suggests that this cirrus may be homologous with the neuropodial cirrus of the Polychæta. The tip of the parapodium appears to be bent over; this is, however, an optical effect due to the shadow thrown by the curved hook within it.

The four pairs of suckers are large, and being unpigmented appear prominent against the dark background; they are raised on muscular prominences and consist of radially folded walls surrounding a small central boss.

Mouth and cloaca are both on the ventral surface, the former

lying a little further in from the margin than the suckers. The pharynx when extended shows a subterminal circlet of ten small tentacles (text-fig. 2 A and B). The intestinal diverticula can

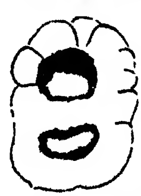
Text-figure 3.



Myzostoma polycyclus, sp. n.
Sketch of abnormal double parapodium and male papilla.

be seen in the smaller more transparent individuals; they extend only slightly beyond the level of the suckers, leaving a narrow marginal zone. The position of the cloacal papilla appears to

Text-figure 4.



Myzostoma polycyclus, sp. n.
Sketch of abnormal double sucker.

vary with the state of contraction of the body; it is, however, approximately on the same level as the suckers.

The male papillæ which are noticeable on most of the specimens are large and have the shape of tall cones with broad bases.

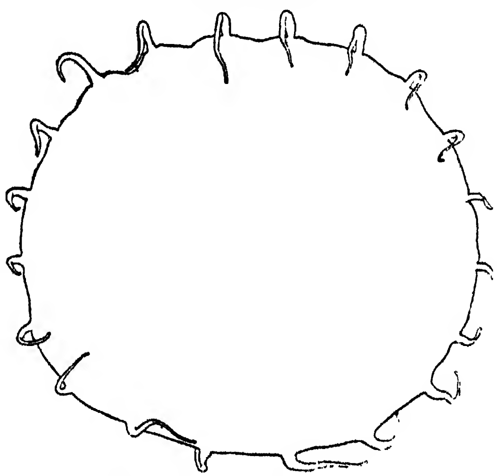
Among the individuals in the collection several abnormalities were met with; a few specimens have less than the normal number of parapodia, one has an abnormal third parapodium on the left side, the distal portion being double (text-fig. 3), while another has a sucker missing, and in another there is a peculiar double sucker (text-fig. 4).

MYZOSTOMA STOCHOEIDES, sp. n. (Pl. I. fig. 4.)

This is another beautiful species, of which five specimens were obtained from *Comanthus annulatus* collected at Badu.

The body is almost circular with an average diameter of 1·5 to 4·5 mm.; the breadth is, however, very slightly greater than the length, this being most noticeable in the smallest specimen (text-fig. 5). The worms are flat, and very thin and membranous, being semitransparent except where the quantity of pigment is

Text-figure 5.



Myzostoma stochoeides, sp. n.

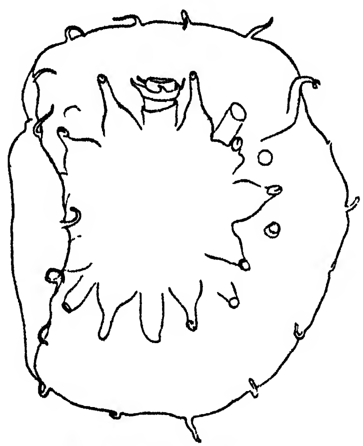
Sketch to show the shape of the body in a young specimen approximately 1·5 mm. in breadth.

greatest; the body disc is slightly thickened from about the level of the parapodial bases to the centre, where the dorsum shows a slight concavity.

The colour-pattern resembles that of *M. polycyclus* in that the dorsal surface is ornamented with concentric darker and lighter rings (Pl. I. fig. 4); these are caused partly by change in the ground-colour, and partly by intensification and reduction respectively of the numerous dark pigment spots which occur over practically the whole surface. The broad outer ring has a

pale grey appearance to the naked eye; the ground-colour is whitish, speckled with dark pigment spots increasing in number towards the inner margin. The next ring, which appears to be nearly cream in tint, is narrow and marks the position of the extended tips of the parapodia; it has a pale yellow ground-colour and the dark spots are much finer and less numerous. The central area is darkest in colour, but has a light streak running through it antero-posteriorly; the ground-colour is pale yellowish-brown and the dark irregular flecks of pigment are very numerous, especially towards the periphery and bordering the light streak; they are arranged roughly in radiating lines giving a slightly streaky appearance to the dorsum. In the smallest individual the rings are not noticeable, the coloration being much more diffuse.

Text-figure 6.



Myzostoma stochoeides, sp. n.

Ventral aspect of specimen 3·65 mm. in length. Only nine pairs of cirri are present.

The central muscular mass, together with the parapodia, suckers, rectum, and pharyngeal region are unpigmented and stand out conspicuously against the surrounding greyish pigmented part of the ventral surface.

There are only ten pairs of marginal cirri; these are slender and longest at the anterior and posterior ends of the body, the fifth and sixth pairs being the shortest (text-fig. 5).

The parapodia are arranged almost in a circle, they are well developed and have much the same structure as those of the preceding species but are, however, relatively larger and their bases are without cirri (text-fig. 6). Conspicuous radial ridges mark the position of the muscles passing from the parapodia to the central muscular mass.

The four pairs of suckers are situated rather far from the margin, they are not extremely conspicuous, but the size varies according to their state of contraction; when well extended their borders appear to be prolonged into a tube-like continuation with very thin walls. The radial muscles running to the suckers are fairly well developed.

The mouth and the cloacal papilla are on the ventral surface about equidistant from the margin and just within the outstretched tips of the parapodia. The pharynx when extended is seen to be crowned with a subterminal circlet of small tentacles, of which five can be counted from the ventral side (text-fig. 6). The cloacal papilla is quite conspicuous. A rounded median longitudinal ridge marks the position of the pharyngeal region and the rectum.

A well-developed male papilla is visible on the left side of a small individual.

Two of the animals have less than the normal number of parapodia, and one of these has only three suckers on one side. The specimen drawn in text-fig. 6 is imperfect in that it has only nine pairs of cirri.

MYZOSTOMA INSIGNE, sp. n. (Pl. II.)

Mr. Potts's collection contains one specimen of a magnificent Myzostomid found on a green form of *Comanthus annulatus*.

The animal, which is roughly circular, is stout and massive with a maximum thickness of about 2·5 mm. The diameter is approximately 8 mm., but, owing to the fact that the right side is considerably contracted, it is impossible to obtain exact measurements. The dorsal surface is vaulted, the thick body thinning out gradually to the narrow, rather translucent margin. The margin is inconspicuously notched, the processes so formed being irregular in size and having swollen bases; there are about twenty of these processes.

The dorsum (Pl. II. fig. 1) is ornamented with marked, clearly defined, truncated ridges, with nearly parallel sides; each ridge is surrounded at some little distance by a line of intense black pigment, giving to the animal a remarkably striking appearance. The lines encircling some of the ridges are not complete towards the periphery. Running antero-posteriorly down the middle line of the worm is a median ridge incompletely divided into four unequal pieces, all enclosed within a single black line. Radiating outwards are five pairs of primary costæ and between them four pairs of much shorter secondary ones, corresponding to the positions of the parapodia and suckers respectively. The costæ leave a semicircular space clear of ornamentation on either side of the long median ridge. When more highly magnified the dorsal surface between the ridges is seen to be divided by a series of furrows into irregular polygonal areas, larger and more clearly marked towards the margin; they are, however, probably due to

contraction and therefore of no systematic importance. The ventral surface is concave.

As mentioned previously this worm was found on a green form of *Comanthus annulatus*, and Mr. Potts states that "It resembled its host closely and was comparatively inconspicuous. The general colour was a bright green; the ridges appeared greenish white, darker at the edges owing to the addition of a granular pigment and round each there was an intense black line" (6). The underside was a vivid blue-green, brownish in the centre; in the preserved state it is of a uniform dirty cream colour. From the collector's field-notes it appears that "the animal moved with a quick jerky movement over the disc" of the Crinoid.

The parapodia are very well developed, extremely strong, and muscular; they are inserted about two-thirds of the radius from the margin. Each parapodium consists of a basal and a much smaller terminal portion. The basal part ends distally in a flattened, rather horseshoe-shaped area, lighter in colour than the rest of the parapodium; from it rises the narrow cone-like terminal portion, provided on the ventral surface with a well-marked groove. The hooks project some little distance, the tips are pale amber in colour, while the shafts are very dark brown.

The four pairs of prominent suckers are at about the same distance from the margin of the body as the distal extremities of the parapodia; they have definite apertures with radially folded walls. They are extremely muscular and are elevated on broad papillæ: rounded ridges connect them with the central muscular mass. Under a higher magnification the muscle-fibres running to the suckers are clearly visible beneath the body-wall (Pl. II. fig. 2).

The mouth and cloaca are ventrally situated close to the margin of the body, though the former is about twice as far from the margin as is the latter. The almost completely retracted pharynx bears a circlet of small tentacles of which eight can be counted. A peculiar elongated tubercle-like process is applied to the ventral surface of the very conspicuous buccal region. The cloacal papilla is extremely prominent, and a broad elevation marks externally the position of the cloaca.

Two specimens taken from a darker variety of *Comanthus annulatus* collected on the reef facing Dauer either belong to the same species or are very closely related. Their preservation is not good, and the original colour is quite lost. One worm measures 5·35 mm. in diameter and about 2·2 mm. in thickness, while the other, which is slightly damaged, has a diameter of about 5 mm.

The sculpturing of the dorsum closely resembles that of the type-specimen; the ridges are broader and not so clearly defined, but this may be due to contraction and also to poor preservation. The arrangement of the small elevations occurring along the middle line is slightly different, and from a sketch of the

collector's it would appear that there was a dark line encircling each of these elevations and not one encircling them all as in the type-specimen. In all three worms the ridges have a peculiar truncated appearance and are not gently rounded as in *M. rubrofasciatum* v. Graff (2, 1). The margin in the last two specimens is entire and without indication of cirri.

Mr. Potts records in his notes a slight difference in coloration between these last two specimens; in one the ridges were yellow, surrounded by a dark line, and the dorsum was brown with an intensification of the colour between the ridges; in the other the ridges were white, surrounded by a purple line, and the colour of the dorsum was a granular brown. The chief difference in colour between these Myzostomids and the type-specimen is in the ground-colour; in the two former it is brown, in the latter green. Such a difference in coloration alone seems insufficient for the creation of another species. Von Graff (2) quoting as examples *M. horologium* and *M. glabrum*, the only two species of which he had abundant material, says how greatly the colour may vary among individuals of the same species and "how unsafe it is, therefore, to fix the limits of a species by its colour. And this is owing to variations in the living animals and not merely to the fact that they are mostly known only by spirit specimens, in which case it is impossible to decide how much of the colour is caused by the alcohol which contains the dissolved pigment of its host."

Myzostoma pottsi, sp. n.

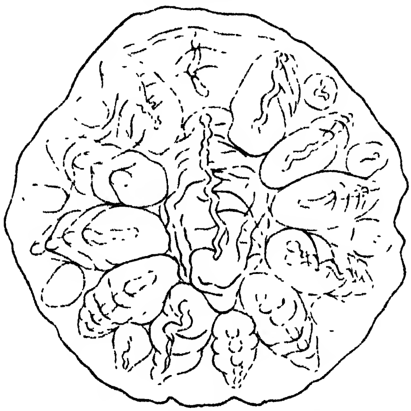
The single example of this species was found on a young stage of an unidentified Crinoid, which it did not match in colour.

The stout body is nearly circular in outline, with a diameter of about 4 mm. The dorsal surface is vaulted, thinning out gradually to the semi-translucent margin. The ventral surface is very slightly concave, but the margin tends to curve dorsally. The dorsum (text-fig. 7) is ornamented with rounded ridges; each of these bears on its summit a lower truncated ridge, with nearly parallel sides, giving to the rounded ridges a crested appearance. Running down the middle of the animal are three ridges in linear series. The anterior one is very slight and indefinite in form; the middle and largest one is much higher and broader; the posterior one is small but well-marked. Radiating from the central elevation are five pairs of primary costæ, and between them four pairs of much shorter secondary ones, corresponding to the positions of the parapodia and suckers respectively. The whole dorsum is much furrowed, due no doubt to contraction and the action of alcohol.

In the living animal the depressions between the radial ridges were dark green in colour, those between the middle elevations and the radial ridges black-green. The middle ridge was cream n colour, with a streak of white with green granules on either

side. The colour of the preserved animal is a dirty brownish-green, with the centre of the under surface more green than brown.

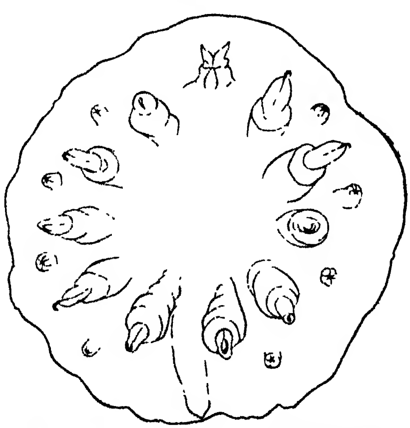
Text-figure 7.



Myzostoma pottsi, sp. n. Dorsal view.

The margin is irregular; there would seem to be indications of two cirri at the hinder extremity, perhaps others may have been lost by abrasion.

Text-figure 8.



Myzostoma pottsi, sp. n. Ventral view.

The structure and position of the parapodia and suckers are essentially the same as in *M. insigne*; the two forms would

appear to be somewhat closely related. Radial ridges connect the parapodia and suckers with the central muscular mass.

The mouth and cloaca are both ventral in position (text-fig. 8), the former being about the same distance from the margin as are the suckers. Applied to the ventral surface of the buccal region is an elongated tubercle-like process as in *M. insigne.* Small tentacles, which probably belong to the partly retracted pharynx, project from the mouth-opening. The cloacal papilla is some distance posterior to the last pair of parapodia and close to the hinder extremity of the body. A longitudinal median rounded ridge on the ventral surface, especially prominent anteriorly and posteriorly, marks the position of the pharyngeal region, stomach, and rectum.

MYZOSTOMA ATRUM, sp. n.

The three examples of this species were collected at different times; two were taken together on October 22nd, 1913, from the purple crinoid *C. pectinata,* while a third and smaller individual was found at a later date.

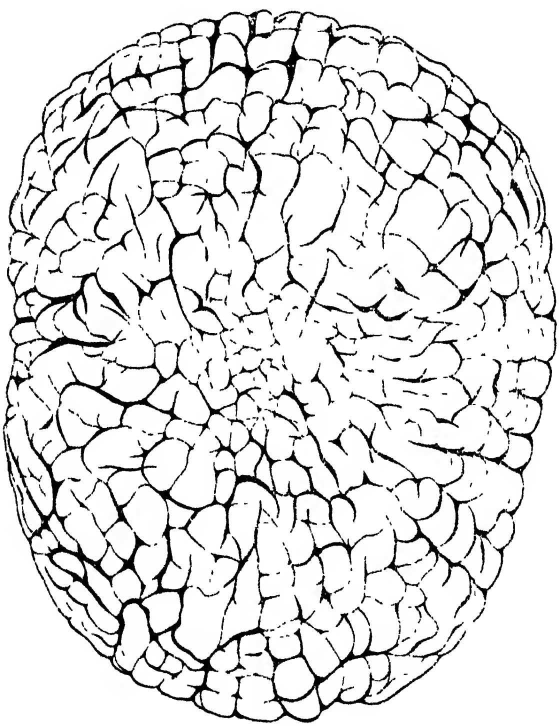
One specimen (text-figs. 9, 10), which is only slightly contracted, has a length of 6·65 mm., a breadth of 5·3 mm., and a maximum thickness of 2 mm. The animal is probably circular in shape, but its true form is somewhat concealed owing to the lateral margins being bent slightly downwards. In the preserved state it appears approximately oval, with broadly rounded anterior and posterior ends. The body is very stout, coarse, and thick, thinning only gradually towards the margin, where it is still of considerable thickness and not at all translucent. The margin is irregular and corrugated but bears no cirri. The dorsum is vaulted; it has rather the appearance of the rough bark of a tree, irregular radial and circular furrows forming irregular areas which are continued on to the peripheral part of the ventral surface. The ventral surface is slightly concave.

Of the remaining two specimens one has a diameter of 4·6 mm. and a maximum thickness of 2 mm., the other a diameter of 4 mm. with a maximum thickness of 1·5 mm. These measurements, however, by no means indicate the size of the living animals, as in the preserved state they are violently contracted, the margin is bent down all round so sharply that it is almost at right angles to the dorsal surface, and the worms appear circular in shape with a down-turned rim, which is very thick, rounded, and corrugated (text-fig. 11). The bent-down margin is furrowed both externally and internally, but the central part of the ventral surface is comparatively smooth, the muscle-fibres passing from the suckers and parapodia to the central muscular mass are visible beneath the body-wall. The dorsal surface is almost smooth, furrows only occurring in a central depression and in two narrow areas running from the anterior to the posterior margin and from left to right. Ten broad cone-shaped prominences

or bosses, corresponding to the insertion of the parapodia, occur round the edge; owing to the animals being in a state of extreme contraction the proximal part of the hook apparatus almost pierces the dorsum and appears at the apex of each prominence as a dark spot (text-fig. 12).

These three specimens illustrate very clearly to what a great extent the general shape and furrowing of the animal depend on

Text-figure 9.



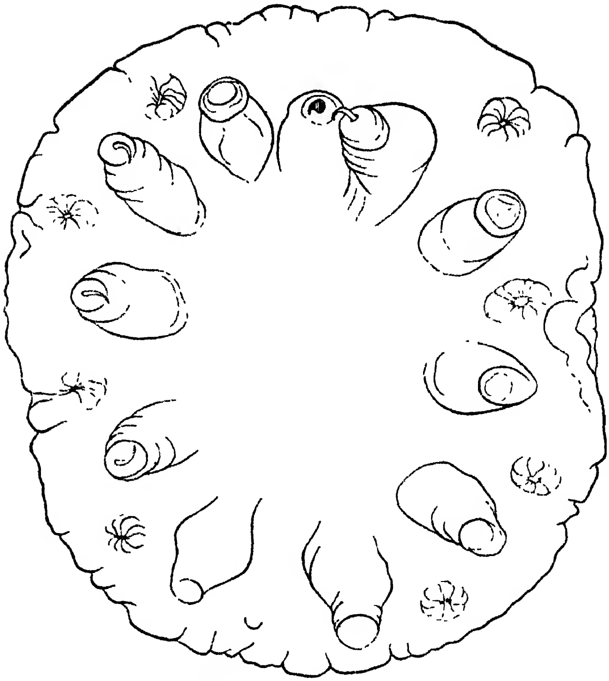
Myzostoma atrum, sp. n.

Dorsal aspect of specimen about 6·65 mm. in length.

the state of contraction it is in when death occurs, and how cautious one should be in using sculpturing as a means of identification.

From the collector's notes it appears that the dorsum was black or dark purple; he found that on washing in water, after fixing in corrosive sublimate, a fine purple pigment came from the animal.

Text-figure 10.



Myzostoma atrum, sp. n.
Ventral aspect of specimen drawn in text-fig. 9.

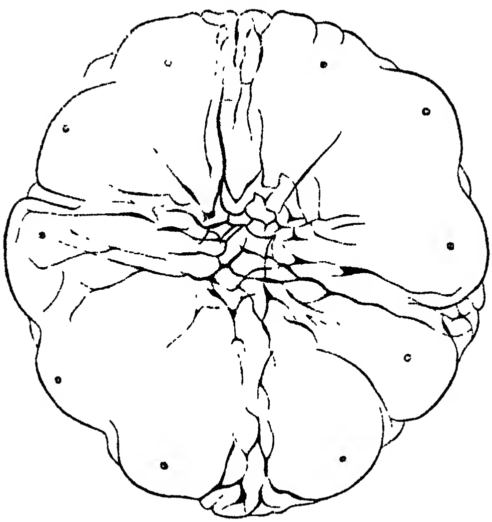
Text-figure 11.

Myzostoma atrum, sp. n.
Ventral view of strongly contracted specimen with a diameter of 4·6 mm.

The parapodia are inserted about a third of the radius from the margin. They are not clearly divisible into two parts, are very stout and clumsy with strongly built hooks. In the smaller contracted specimen the middle parapodium of the right side is reduced to a mere stump.

The four pairs of suckers are situated rather close to the margin; they have definite apertures which have very thick lips with radially folded walls. Owing to the fact that they are not

Text-figure 12.



Myzostoma atrum, sp. n.

Dorsal view of specimen shown in text-fig. 11.

raised on papillæ and are of the same colour as the rest of the ventral surface, they are not very conspicuous; indeed, some of the suckers are rather difficult to make out, as they have become involved in the folds of the body.

The inconspicuous cloacal papilla is on the ventral surface about the same distance from the margin as are the suckers, while the mouth is about twice as far. The position of the pharyngeal and cloacal regions is marked by two slight ridges.

Myzostoma viride, sp. n.

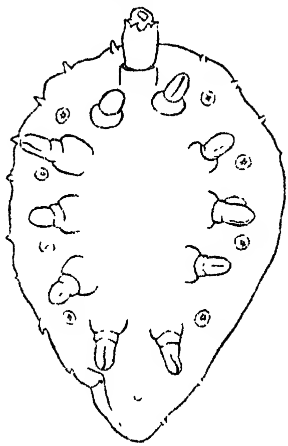
In Mr. Potts's collection are four specimens of a Myzostomid taken from *Comanthus annulatus*.

Three of the worms measure 2·6 mm. each in length, while a fourth and larger one is 3·7 mm. long with a maximum breadth of 2·55 mm. The breadth of the three smaller individuals could

not be ascertained, as they are contracted with the sides sharply incurved ventrally (text-fig. 14); in these the anterior and posterior margins are broadly rounded. The large specimen (text-fig. 13) tapers almost to a point posteriorly, but this may be abnormal, as the right side is slightly faulty. The body is stout and fairly thick, increasing slightly in thickness towards the middle line, while there is only a very narrow semi-translucent margin. The dorsum of the uncurled specimen has a few irregular folds, due no doubt to artificial causes.

In the living animal the dorsal surface was a dark green, only relieved by a white line down the middle; the extended pharynx was red. The colour in the preserved state is a light brown with a paler streak running down the middle of the dorsum.

Text-figure 13.



Myzostoma viride, sp. n.

Sketch of the ventral surface of uncurled specimen.

There are twenty marginal processes, finely pointed and triangular in shape. These are rather inconspicuous in the uncontracted worm but clearly visible in the curled up individuals.

The parapodia are well developed; each consists of a short, broad, very muscular basal portion and a narrower terminal portion, grooved ventrally. The distal end of the basal portion encircles the terminal part like a tightly fitting, thin collar. The parapodia, when extended, reach almost to the body-margin. The muscle-fibres from each are gathered into well-defined bundles, which rise above the surface as sharp ridges, and pass into the central muscular mass.

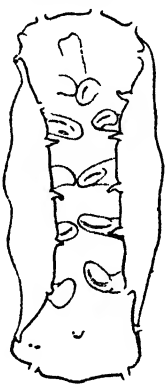
The four pairs of fairly conspicuous suckers are in the normal position; their rather indistinct apertures appear as slight

depressions; when more highly magnified they are seen to have radially folded walls.

The mouth and cloaca are ventral and subterminal. The extremely strong and muscular pharynx bears a circlet of small triangular tentacles, of which four are visible from the ventral side. The inconspicuous cloacal papilla lies well behind the last pair of parapodia. A rounded median longitudinal ridge marks the position of the stomach and rectum.

A male papilla is visible in the large worm just anterior to the third parapodium on the left side.

Text-figure 14.



Myzostoma viride, sp. n.
Sketch of curled specimen.

This species resembles *M. wheeleri* McClendon (**5**) in its general shape and size, and to a less extent *M. folium* v. Graff (**2**) and *M. nanseni* v. Graff (**3**). *M. wheeleri* had "its lateral margins bent downwards, probably to grasp the pinnæ, making the dorsal surface very convex and the ventral very concave" (**5**). This also occurs in three out of the four specimens of *M. viride*, but here may be due to contraction on killing. *M. viride* is clearly distinguishable from *M. wheeleri* by the presence of suckers, by the much stouter pharynx, and the shorter cirri.

Myzostoma gardineri, sp. n.

Prof. J. Stanley Gardiner obtained the two specimens of this species from an unidentified Crinoid collected from Hulula Malé Atoll in the Maldives.

The larger specimen (text-fig. 15) has a length of 3·9 mm. and a breadth of 2·8 mm.; the smaller a length of 2 mm. and a breadth of 1·17 mm. The worm is oval in shape, the body thin, and in the smaller specimen almost transparent, even the larger

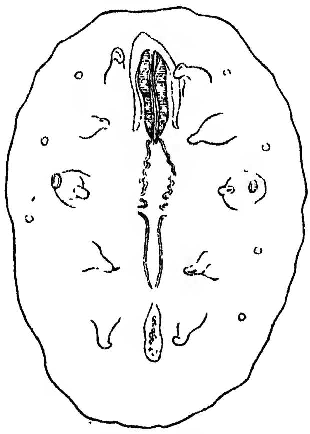
one being so to a certain extent, especially near the margin. The dorsal surface is slightly convex, without ridges, and the ventral slightly concave.

The dorsum in the preserved animal is a pale sepia brown fading towards the margin; a light coloured streak marks the middle line.

The margin of the larger specimen is somewhat irregular, but it is impossible to make out any cirri; their absence is probably due to abrasion, for in the smaller worm the bases of at least six cirri remain on one side.

The feebly developed parapodia are arranged in two almost parallel rows; they are not clearly divided into two parts and are not grooved.

Text-figure 15.



Myzostoma gardineri, sp. n.

Sketch made from the larger specimen cleared in cedar-wood oil.

The suckers are very indistinct, being extremely difficult to find; in the smaller specimen they appear to be absent altogether, although a careful search was made for them, and in the larger one the fourth sucker on the right side could not be discovered.

The position of the mouth is very near the anterior end of the body; the strong pharynx is retracted. The aperture of the cloaca is about twice as far from the posterior end as the mouth is from the anterior. The intestinal diverticula extend almost to the margin of the body, leaving only an extremely narrow, clear border. On the ventral surface a rounded and pale-coloured median longitudinal ridge marks the position of the stomach and rectum.

This is a very generalized form; it has some resemblance to *M. viride*, but is not nearly so stout and strong, the parapodia

and especially the suckers being relatively feebly developed. As the pharynx is retracted in both specimens it is impossible to ascertain whether it bears papillæ as does that of *M. viride.*

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EXPLANATION OF THE PLATES.

Plate I.

Figs. 1-3. *Myzostoma polycyclus*, sp. n. Figs. 1 and 2 dorsal views showing extremes in the development of the rings. Fig. 3, ventral view of a third specimen. × ca. 14.

Fig. 4. *Myzostoma stochoeides*, sp. n. Dorsal aspect. × ca. 14.

Plate II.

Figs. 1-2. *Myzostoma insigne*, sp. n. Dorsal and ventral aspects. × ca. 11.

22. On *Sphenosuchus*, and the Origin of the Crocodiles. By R. Broom, M.D., D.Sc., F.R.S., C.M.Z.S.

[Received March 28, 1927: Read May 10, 1927.]

(Text-figures 11–15.)

The Crocodiles form such a homogeneous group, the lowest being essentially so similar to the highest that there has always been much difficulty in fixing the probable ancestor.

The Phytosaurs have frequently an exoskeleton so suggestive of that of the Crocodiles as to readily lead one to the conclusion that the Crocodilian ancestor may have been a Phytosaur. Still, when the detailed structure of the Phytosaurs becomes better known it becomes manifest that while perhaps the Phytosaurs and Crocodiles might be parallel groups from some unknown common ancestor, the former could not have been directly ancestral to the latter.

When *Aëtosaurus* was described by Fraas in 1877 it seemed as if in this little Crocodile-like reptile we might have the ancestor, and Zittel placed it in a group, the Pseudosuchia, which he and others regarded as a suborder of the Crocodilia. Von Huene's more detailed researches on the anatomy of *Aëtosaurus* seem to show that though it may be allied to the ancestral Crocodile it cannot itself be the ancestor. Both the skull and the pelvis differ very markedly from what we should expect in the Crocodilian ancestor.

Still, though *Aëtosaurus* may not be the ancestor, as time goes on it becomes more and more manifest that the group Pseudosuchia, into which a considerable number of Triassic two-arched reptiles have been placed, probably represents the Order some member of which was the ancestor of the Crocodiles.

The Pseudosuchia as at present understood includes forms which are near the ancestors of the Birds and Pterodactyles, forms which probably are ancestral to the Dinosaurs, and others which clearly show affinities with the Crocodiles.

In South Africa we have at least three forms which may be regarded as showing Crocodilian affinities, and one of these I think is very near to the Crocodilian ancestor.

Over twenty years ago I described under the name *Proterosuchus* an imperfect skull from beds which are perhaps of Middle Triassic age. It is perhaps the oldest Pseudosuchian known, and though unfortunately too imperfect to enable one to say much about it, it seems to be near what one would expect to find as the ancestor of *Sphenosuchus*.

Sphenosuchus acutus from the Red Beds was first described by Haughton in 1915, and has been redescribed by him recently and also by v. Huene. The specimen consists of a nearly perfect

though somewhat crushed skull, a nearly perfect shoulder-girdle, and some limb-bones. But though all the more important bones have been figured by both Haughton and v. Huene, new drawings of the skull with the crushing corrected will not, I think, be superfluous, especially as in one or two points I think both Haughton and v. Huene are slightly in error. (Text-fig. 11.)

In general structure the skull agrees fairly closely with that of *Euparkeria*, differing mainly in having no postfrontal or interparietal bones and in having the quadratojugal widely separated from the squamosal.

The premaxillary bones are imperfect in front, and both Haughton and v. Huene regard the nostrils as probably confluent. I see no reason to think so, and consider it much more probable that there was, as in most reptiles, an ascending internasal process from the premaxillaries. Haughton figures five very slender teeth in the premaxillary, and v. Huene also figures the teeth as small. In my opinion there are three teeth in the premaxilla not much inferior in size to those in the maxilla. In the specimen they are badly crushed.

The antorbital vacuity is relatively smaller than in *Euparkeria* and *Ornithosuchus*, but is apparently similar in structure.

The nasals are long and narrow and pass from near the plane passing through the front of the orbits to the extreme anterior point of the snout.

The lacrimal and prefrontal are as I indicate in the figures given. (Text-figs. 11, 12.)

The frontals are relatively large and form a small part of the upper orbital margin, and much of the anterior part of the upper temporal fossa.

The jugal is, as in most Diaptosaurians, a large bone, which forms the whole of the lower orbital bar and practically the whole of the lower temporal bar.

The postorbital bone is a triradiating element with an anterior portion which forms part of the upper orbital margin, a posterior process which articulates with the squamosal, and a descending portion which meets the jugal and forms most of the postorbital bar.

The parietal is a fair-sized element which forms practically the whole of the intertemporal region and a considerable part of the occiput. There is no parietal foramen.

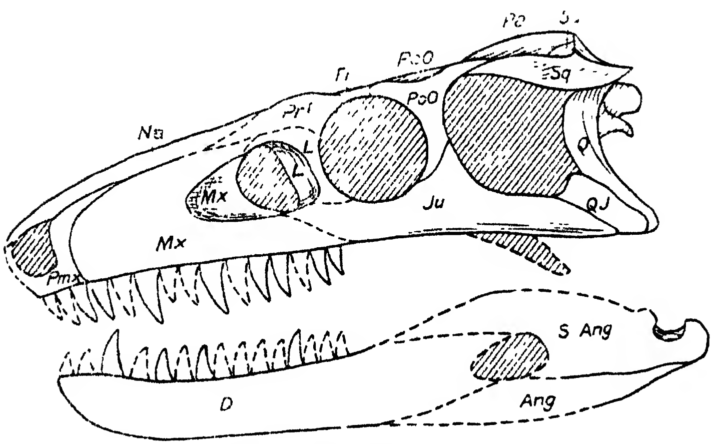
The squamosal is a long bone which forms the greater part of the upper border of the lower temporal fossa. It also forms the posterior half of the intertemporal bar as seen from above. The posterior end of the bone is closely articulated with the parietal and forms with it the upper half of the outer part of the occiput. It also gives articulation to the upper end of the quadrate and the outer part of the paroccipital.

The quadrate is a long, rather narrow bone, as shown in the figures. On its outer side is a small plate-like quadratojugal, which also articulates with the jugal.

The occiput is well preserved. Above the foramen magnum is an unpaired supraoccipital. Lateral to the supraoccipital is the occipital portion of the parietal, and lateral to the parietal the occipital portion of the squamosal. Below the squamosal and the parietal is a large paroccipital with the fused exoccipital. The condyle is of the usual reptilian rounded form.

The palate is nearly complete, and shows a number of characters which have not previously been observed. The anterior portion has not been cleared of matrix, but is probably much as I have restored it. The palatine is almost completely and perfectly preserved. It has a long outer articulation with the maxilla and the jugal, and a process forms an articulation with the ectopterygoid. Anteriorly there is a concavity which

Text-figure 11.



Skull of *Sphenosuchus acutus* Hgtn. Side view.

I believe to be the posterior end of the internal nares. Internally there is a long articulation with the anterior process of the pterygoid. On the left side this is nearly complete, and the anterior portion, which is lost on the left side, is seen on the right.

The ectopterygoid is a short, rather robust bone which articulates externally with the jugal, and has a small internal articular surface for the pterygoid.

The pterygoid is a large element, and nearly perfectly preserved. It has a long slender anterior process closely articulating with the process of the other side and doubtless meeting the prevomer, though the anterior end of the bone is not displayed. On the outer side of most of this process lies the palatine. Posteriorly the pterygoid is widely expanded, the anterior outer corner of which expansion articulates with the ectopterygoid. Almost the whole of this large posterior expansion is lost but

practically the complete impression is preserved on the matrix, so that the outline can be given with certainty. Internally the posterior part of the pterygoid passes rather abruptly and far upwards to articulate with the basisphenoid, and it also sends a process to articulate with the quadrate.

The basisphenoid, basiocciput, and bones of the side of the brain have been described in detail by Haughton, but there is one point the importance of which has, I think, been overlooked by both Haughton and v. Huene. It seems to me that two deep pits or foramina in the front of the basioccipital and adjoining the suture with the basisphenoid, described by Haughton, are really the Eustachian canals.

There is nothing to add to Haughton's description of the occiput.

The mandible is fairly well preserved, only a small portion from near the middle region being missing, and as the upper jaw from the snout to the quadrate can be restored with confidence, we can restore the mandible with equal confidence.

The dentary is rather slender and of moderate length. It appears to have fourteen teeth, of which the third is a little larger than the others. On the outside of the dentary is a large splenial which forms practically the whole of the inner side and which extends into the symphysis.

The back portion of the jaw is well preserved, and in the specimen has most of its outer aspect displayed. There is a large surangular and a smaller angular, as I show in the figure. Each bone is cut off in front by an oblique fracture, but portion of what appears to be a fracture of the surangular is really the posterior wall of the large lateral vacuity of the jaw. The angular does not reach the preserved portion of the front of the jaw except as a spur which is enclosed by the dentary and the larger splenial.

The shoulder-girdles of each side are well preserved, and though they have been figured by Haughton and v. Huene a third independent figure slightly restored will not, I think, be superfluous.

The scapulæ and coracoids of each side are in almost undisturbed relations with each other, so that it is possible to give a restoration which must be very nearly correct. Haughton and v. Huene both figure the coracoid as having a notch in its upper border, and in the specimens as preserved this is undoubtedly the condition. But it seems to be highly probable that a little of the upper border has been broken off and that the coracoid foramen was completely enclosed by bone as in most reptiles. The interclavicle is almost perfectly preserved.

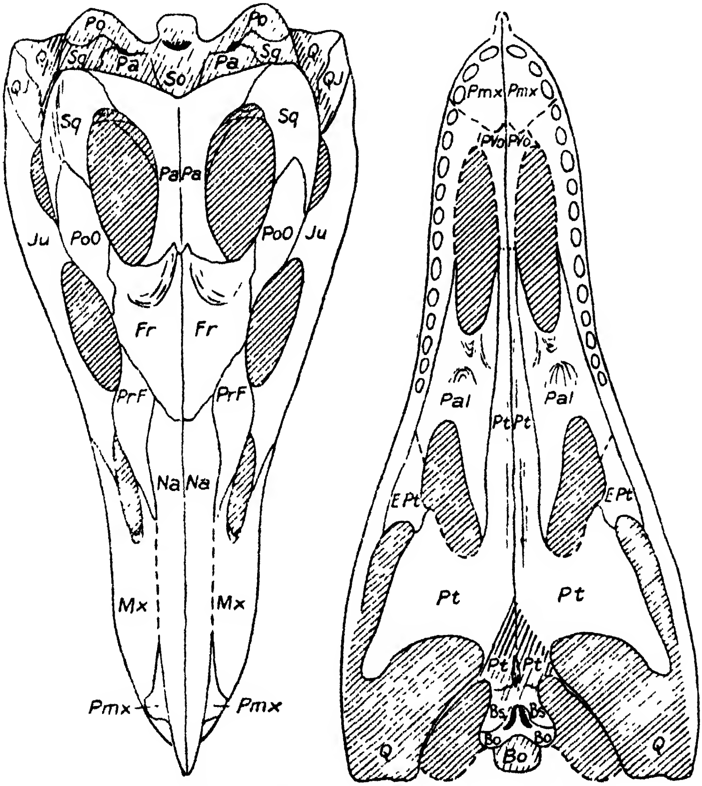
The limb-bones preserved do not help us much in determining the affinity of *Sphenosuchus*, but show that it was an animal with rather long slender subequal limbs, and very unlike the condition we find in the possibly allied *Pedeticosaurus*, where the hind limbs are very much larger than the anterior.

Unfortunately there is no trace of the pelvis preserved.

In the absence of the pelvis, carpus, and tarsus it is impossible to say how near *Sphenosuchus* comes to the Crocodiles, but in those parts of the skeleton preserved we certainly have some striking resemblances.

The skull is moderately deep, while the skulls of all true Crocodiles are considerably flattened; but apart from this there

Text-figure 12.



Upper and under views of skull of *Sphenosuchus acutus* Hgtn.

is not, so far as I can observe, a single feature that is not crocodilian or proto-crocodilian.

The peculiar large upward and backward process of the premaxilla which ascends behind the nostril and passes backwards between the nasal and the maxilla, is a very unusual character in reptiles. It is met with to some degree in other Pseudosuchians such as *Euparkeria*, and in the primitive Phytosaurian *Mesorhinus*, and it is also met with in most Ornithischian Dinosaurs,

but in no other reptiles except in some crocodiles. Yet it seems moderately certain that this must have been a character of the primitive Crocodiles, and that the condition we find in most crocodiles, where the nostrils are completely surrounded by the premaxillaries, has resulted from the backward withdrawal of the nasals. In *Alligator*, where the nasals still divide the nostrils, the condition is essentially similar to that in *Sphenosuchus*.

The other features of the top of the skull are all such as we should expect to find in an ancestral Crocodile. The absence of a postfrontal bone, and of a pineal foramen, with the frontal forming a considerable part of the orbital margin and entering largely into the temporal fossa, is a group of characters all typically crocodilian and met with in no other order.

The side of the skull with the large antorbital opening is less crocodile-like owing to most Crocodiles having lost the antorbital opening. But a few primitive Crocodiles still preserved the opening, and the opening was only lost when the skull became flattened. All the other characters are such as we should expect to find in the ancestral Crocodile. The quadratojugal is almost typically crocodilian, and unlike that of any other reptilian order.

The occiput is almost typically crocodilian.

The palate, though with no trace of a secondary palate, is such as the ancestral Crocodile is likely to have had. A somewhat similar palate is met with in the Pseudosuchians *Proterosuchus*, *Erpetosuchus*, and *Ornithosuchus*, but among later forms only in the Crocodiles, though here it is obscured by the development of a secondary palate. If the pits between the basioccipital and the basisphenoid are correctly identified as the Eustachian canal, then we have a character met with elsewhere only in the Crocodiles.

The mandible, though not fully known, also approaches closely that of the Crocodile. The large surangular and angular divided in front by the large lateral vacuity is a character found in the Pseudosuchian *Euparkeria*, and is met with in many of the more primitive Dinosaurs. But the nearest approach to the condition in *Sphenosuchus* is seen in the Crocodiles. The transverse fracture which is shown near the middle of the jaw shows a condition very similar to that of a crocodile. v. Huene figures this section, but what he marks "angular" is in my opinion a fractured portion of the splenial, and the little internal spur between the splenial and the dentary which he calls "prearticular" is in my opinion the anterior spur of the angular. It was correctly identified by Haughton.

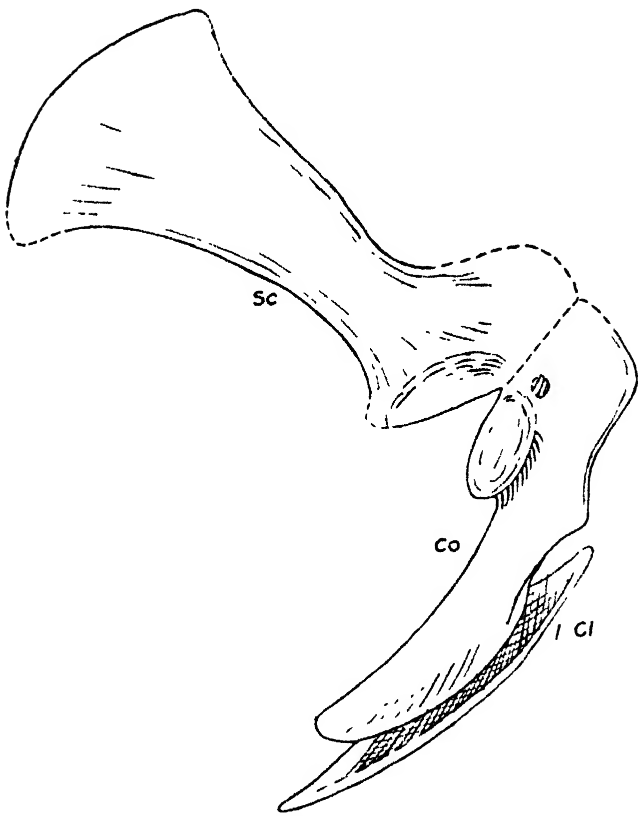
The shoulder-girdle, the only other part preserved that helps us in determining the affinity, is typically crocodilian in all details. (Text-fig. 13.)

On the evidence which we have, I think we may conclude that

Sphenosuchus is a Pseudosuchian which is well advanced along the line which leads to the true Crocodiles.

There are two other South African forms which must here be considered. In 1904 I described what I believed to be two primitive crocodiles under the names *Notochampsa istedana* and *Notochampsa longipes*. The former specimen consists of much of

Text-figure 13.

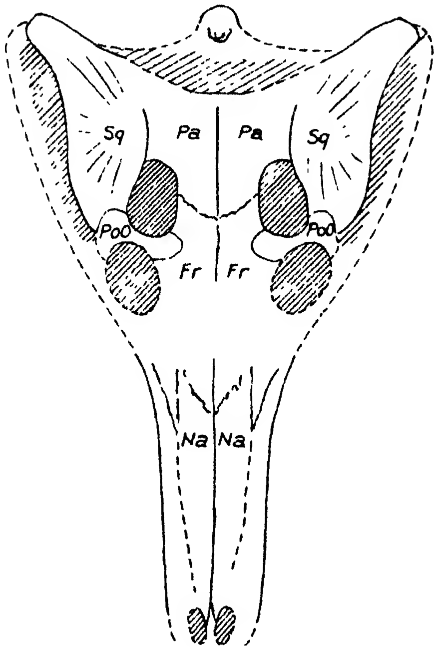


Right shoulder-girdle of *Sphenosuchus acutus* Hgtn.

the body with scutes, an imperfect skull, a good shoulder-girdle, and much of the limbs; the latter specimen consists of a good pelvis, and hind limb, part of a front limb, and a number of scutes. In the absence of well-preserved corresponding parts in the two specimens, it is impossible to be sure that they belong to the same genus, and Haughton has placed the less perfect specimen in a new genus *Erythrochampsa*, and in this he has

been followed by v. Huene, and until other more perfect specimens are obtained it will avoid confusion to use the two generic names. Haughton has, however, gone further. He regards *Notochampsa istedana* as a Pseudosuchian or Archosaurian allied to *Pedeticosaurus*; while *Erythrochampsa* he doubtfully places in the Crocodilia. v. Huene regards *Notochampsa* and *Erythrochampsa* as allied genera, and places both in the Pseudosuchia. After a very careful examination of both specimens and a full consideration of the views of Haughton and v. Huene, I am still

Text-figure 14.



Skull of *Notochampsa istedana* Br.
Restored parts in dotted line.

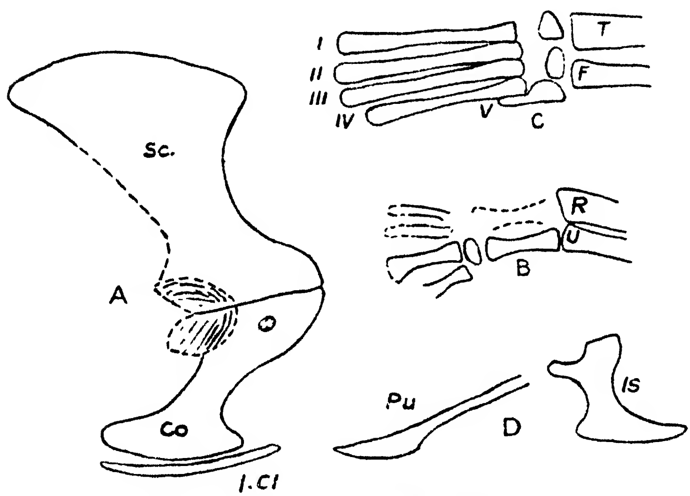
of the opinion I was in 1904, that the two forms are closely allied and that both are true Crocodiles.

The skull of *Notochampsa* was figured by me in 1904 slightly restored. A careful drawing of the skull as preserved was given by Haughton in 1924, and another drawing of the skull as preserved by v. Huene in 1925. These drawings are sufficient to show that the specimen is far from satisfactory. The matrix is a soft sandstone, and as only the impressions of the bones remain and the whole frontal region has been destroyed and the

point of the snout and the jugal region lost, it is perhaps not surprising that there are different interpretations of the portions that remain. But as the specimen is of very great importance it seems necessary to attempt a further more careful restoration.

The snout is long and narrow and flattened as in many crocodiles. There are a few unsatisfactory impressions of sutures, but no clear indications as to which bones formed the top of the snout. Most probably the condition was as I restore it. In my first restoration I figured the nostrils as perhaps united. A further development of the specimen showed an anterior point to the nasal, and indicated that the nostrils are divided as figured

Text-figure 15.



A. Shoulder-girdle of *Notochampsa istedana* Br.
B. Carpus of *Notochampsa istedana* Br.
C. Tarsus and metatarsus of *Erythrochampsa longipes* Br.
D. Pubis and Ischium of *Erythrochampsa longipes* Br.
All nat. size.

by Haughton and v. Huene. v. Huene believed there is a small antorbital opening. Haughton has been unable to decide whether there is one or not, and I incline to the opinion there is none. (Text-fig. 14.)

Haughton places the eye a little further forward than I do. When the specimen was first found I was of opinion that portion of the orbital margin could be traced on the front of the post-orbital. With handling the soft sandstone has got a little rubbed and the orbital margin can no longer be clearly seen.

Much of the structure of the top of the back half of the skull can be clearly made out. The supratemporal openings are fairly

well preserved and the whole of the parietals and much of the frontals. Laterally there is a huge squamosal. In the specimen as preserved this large bone, which I regard as squamosal, is divided by a crack or suture on the right side, and Haughton regards the inner part as top of the quadrate, and v. Huene believes it to be the postorbital. In 1904 I was of opinion that the division was merely a crack, and I am still of this opinion. On the left side there is no corresponding division of the bone; and, further, the fibres of the bone radiate undisturbedly over the crack. What is manifestly the postorbital is seen in front of the squamosal.

The shoulder-girdle is fairly well preserved and typically crocodilian. v. Huene considers a small bony fragment as representing the clavicle. I regard it as merely a displaced scute, and believe there is no clavicle. (Text-fig. 15 A.)

When I first examined the specimen the fore limb had not been displayed. Now there can be seen not only part of the humerus, but much of the radius and ulna, much of the carpus and the metacarpals. And here we find the strikingly crocodilian character, a carpus with the radiale and ulnare elongated and metacarpal-like in structure. (Text-fig. 15 B.)

The hind limb is fairly well preserved and not much longer than the anterior.

The preserved portions of *Notochampsa* all seem to me to confirm the view that it is a true Crocodile. The skull, while differing considerably from that of any known crocodile, agrees essentially with that of the small Upper Jurassic *Alligatorellus*, and if *Notochampsa* had a short snout instead of a long one the agreement would be striking. The resemblance in skull, limbs, and scutes is such that I do not hesitate to affirm that *Notochampsa* is fairly closely allied to *Alligatorellus*, and a true Crocodile.

Erythrochampsa is admitted by Haughton to be probably a true Crocodile, and v. Huene, though he regards it as a Pseudosuchian, recognises its crocodilian affinities. Unfortunately we have little more evidence than that supplied by the scutes, the pelvis, and the tarsus and metatarsus. The scutes are very similar to those of *Notochampsa*, but as of course somewhat similar scutes are found in so many different forms little reliance can be placed on the evidence. The pelvis, however, is admitted by all to be typically crocodilian. In no other group are a pubis and ischium formed on this type. The tarsus and metatarsus are also quite crocodilian in structure, and very similar to those of *Alligatorellus*. (Text-fig. 15 C, D.)

I therefore feel compelled to place *Erythrochampsa* in the same family as *Notochampsa*, the Notochampsidæ of Haughton, and to regard the family as one of true Crocodiles, not far removed from the Atoposauridæ.

v. Huene has just published a paper on the origin of the Crocodiles, and the importance of *Sphenosuchus* as a stage in the

evolution. The steps in the development he believes to have been *Erpetosuchus*, *Aëtosaurus*, *Stegomosuchus*, *Sphenosuchus*, *Pedeticosaurus*, and presumably *Notochampsa* and *Erythrochampsa*, all of which he regards as Pseudosuchians.

Erpetosuchus is not very fully known, and it seems to me too specialised to have been on the crocodilian line. *Aëtosaurus* is doubtless in some respects crocodile-like, but it seems to me also too specialised to have been in the direct line. *Stegomosuchus*, though possibly not far from the crocodilian ancestor, is too imperfectly known to enable us to fix its position. *Pedeticosaurus* is fairly well known by much of a good skeleton. It is a Pseudosuchian with the hind limbs greatly developed. Both v. Huene and Haughton consider it to be nearly allied to *Notochampsa*, with which view I cannot at all agree. The skull, so far as can be seen in the type and only known specimen, is apparently in structure pretty similar to that of *Sphenosuchus* though differing in a number of details. The shoulder-girdle is also probably somewhat like that of *Sphenosuchus*. The carpus is clearly not elongated as in the crocodile, and though the pelvis is not preserved it seems probable the pubis resembles that of *Ornithosuchus*. It seems to me that *Pedeticosaurus* is an ally of *Sphenosuchus*, which by becoming bipedal in habitus definitely left the line of Crocodilian evolution.

The South African rocks yield us the only important evidence we have of the origin of Crocodiles. In the first place we have, as I believe, definite Crocodiles in beds which we have now good reason to believe are not later than Rhætic, while in no other part of the world are Crocodiles known earlier than Lower Jurassic, and our Crocodiles are already considerably specialised. We also have in *Sphenosuchus* evidence of a group of Pseudosuchians which in many characters foreshadow the Crocodiles, and we have in *Proterosuchus* evidence of forms which are probably ancestral to the *Sphenosuchus* group. In time we will get many more stages in the line of Crocodile evolution in our South African beds.

What has probably happened is that a group of Pseudosuchians not very far removed from the generalised *Euparkeria* left the dry ground and took to living in the marshes, and developed comparatively feeble long limbs and ultimately flattened skulls with all the changes in structure that characterise the Crocodiles. Other groups that found it more convenient to live in the dry land became bipedal and gave rise to the Theropodous Dinosaurs and Birds.

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References to Lettering.

Ang., Angular; *B.O.*, Basioccipital; *B.S.*, Basisphenoid; *Co.*, Coracoid; *D.*, Dentary; *E.Pt.*, Ectopterygoid; *F.*, Fibula; *Fr.*, Frontal; *I.Cl.*, Interclavicle; *IS.*, Ischium; *Ju.*, Jugal; *L.*, Lacrimal; *Mx.*, Maxilla; *Na.*, Nasal; *Pa.*, Parietal; *Pal.*, Palatine; *PrF.*, Prefrontal; *Pmx.*, Premaxilla; *P.O.*, Paroccipital; *Po.O.*, Postorbital; *Pt.*, Pterygoid; *P.Vo.*, Prevomer; *Pu.*, Pubis; *Q.*, Quadrate; *Q.J.*, Quadratojugal; *R.*, Radius; *S.Ang.*, Surangular; *Sc.*, Scapula; *Sq.*, Squamosal *T.*, Tibia, *U.*, Ulna.

23. On Mammals from the Gobabis district, Eastern Damaraland, South-West Africa, obtained during Captain Shortridge's fourth Percy Sladen and Kaffrarian Museum Expedition. With Field-notes by the Collector. By Oldfield Thomas, F.R.S., F.Z.S.

[Received December 22, 1926: Read March 22, 1927.]

For the fourth time, by the generosity of the Percy Sladen Trustees and the Administrator of the South-West African Territory and with the cordial co-operation of the Trustees of the King William's Town Museum, Captain Shortridge has been enabled to make a collecting expedition into the interesting region of the mandated Territory of South-West Africa. Each of the four expeditions has been carried out in a distinct and special region of the South-West African area, and each has added materially to our knowledge of the local fauna.

The first expedition was to the middle Orange River, the second to Damaraland—otherwise Hereroland, Southern South-West Africa, and the third to Ovamboland and the Cunene River in the northern part of the territory.

On the results of these expeditions, papers were contributed to the Society in 1923, 1925, and 1926.

Now comes the fourth collection, which is magnificent in extent, but owing to the regions visited being all very uniform, on the inland plateau away from the diversified coastal region, the fauna is poorer in its number of species as compared with that dealt with in the previous papers of the series.

Even then, however, there are no less than 55 species and subspecies represented, while in the number of individuals and perfection of preparation, the collection exceeds any of the former South African sets. It contains just on 1000 specimens, and of the 55 forms included, besides additional series of species previously discovered by Captain Shortridge, five have still to be described as new.

The fauna in the present area is naturally most like that described in the second paper, from Damaraland in the Southern half of British South-West Africa, diluted with a greater tendency to a desert specialization, the localities lying more towards the Kalahari desert.

The appreciation of the generosity and public spirit shown by the Percy Sladen Trustees and by the Trustees of the Kaffrarian Museum published in the former papers applies equally to the present case, and the scientific value of the help thus given to the faunistic exploration of this important area cannot be exaggerated.

I should also lay stress on the unstinted assistance given to

Captain Shortridge by various local Officers and residents, and most especially by Mr. Harold P. Smit, the Secretary for South-West Africa, through whom the collector received assistance in many different ways and notably in the financial aid contributed by the South-West African Government. Incidentally this help by the Government indicates how great a value is there placed on such an exploration as Captain Shortridge has carried out. And to Lieut. C. H. Hahn, M.B.E. (in charge of native affairs, Ovamboland), Captain Shortridge has been greatly indebted in many ways both personal and official.

The localities at which Captain Shortridge worked are all within a comparatively short distance of Gobabis, and to the eastward of it, about 22° S. and 20° E., and all are at fairly similar altitudes. Gobabis itself is 4650′; Sandfontein 4100′; Stampriet 4850′; and Karolinenhof 4000′. And as the character of the country is also somewhat uniform, only being more desert to the eastward, the fauna is naturally more uniform than those represented in the previous collections, one form of each type being alone represented.

As usual Captain Shortridge has contributed accounts on the habits and distribution of the various members of the Mammalian Fauna; and these are so full as to make the paper a fairly complete account of the Mammals of the Gobabis district. The native names for the species used by the various local tribes have also been recorded by Capt. Shortridge, and will it is hoped be later published under his own name.

1. Papio porcarius Bodd.

♂. 2380, 2554. N. of Gobabis.
Separate skull. Oas.

2. Nycteris damarensis Pet.

♂. 2024. Sandfontein.
♂. 2419, 2429, 2434, 2438. Karolinenhof.

"Not uncommon in the attics of empty houses, in wells, &c. in Gobabis district.

Nycteris has the same habit as *Megaderma* of entering verandahs and picking large insects, spiders, etc. off the walls, but unlike the members of that genus, does not appear to prey on mice, frogs, or lizards, nor to attack cage-birds."—G. C. S.

3. Eptesicus capensis damarensis Noack.

Forty-six skins and thirteen in spirit from Sandfontein, Gobabis, Stampriet, and Karolinenhof.

In the previous paper *E. damarensis* was recognized as a distinct species from *capensis* on the basis of its lesser size, but among the present series there are many as large as the type of the latter, and I therefore place the local form as a subspecies of *capensis*, characterized by its paler coloration.

4. Miniopterus smitianus, sp. n.

♂. 2564. ♀. 2567. Witvley, 40 mi. W. of Gobabis.

A pale greyish form related to *M. dasythrix.*

Size slightly less than in *dasythrix*, greater than in *fraterculus.* Fur of head velvety, the hairs standing upright; elsewhere lying smoothly backwards. General colour of whole upper surface of male, and of hinder back of female smoky-grey, near "mouse-grey" of Ridgway; quite different from the brown of various depths found in other forms. Anterior half of female dull cinnamon above. Under surface of male slaty-grey, like the back, of female dull cinnamon: in both there is a well-marked whitish transverse band across the inguinal region and base of tail. Colour of membranes throughout greyer and less brown than usual.

Skull about as in *dasythrix.*

Dimensions of the type:—

Forearm 45 mm. (of male paratype 46).

Head and body 62 mm.; tail 58; ear 12. Third finger, metacarpus 41; first phalanx 11.

Skull: greatest length 15·0 mm. (of ♂ 16); breadth across brain-case 8. Front of canine to back of m^3 6.

Hab. as above.

Type. Adult female. B.M. No. 26.12.7.15. Original number 2567. Collected 16 January, 1926.

Here again, as with other forms of the general area, the local *Miniopterus* takes on a grey shade, in contrast with the brown, light or dark, of other representatives of the genus.

Named in honour of Mr. Harold Smit, whose many acts of assistance to Capt. Shortridge have been already referred to.

The dried *Miniopterus* picked up in the Etosha Pan, Ovamboland, and referred in the previous paper to *M. natalensis*, is no doubt an example of *smitianus*, though its condition renders certain identification difficult.

"Only seen around Witvley, where it seemed to be fairly plentiful, and in the habit of entering houses.

Bats are not specially numerous in the Gobabis district, conditions, except in the few hills on its western border, not being favorable, as in Windhoek, for large concentrations of the cave-dwelling species."—G. C. S.

5. Elephantulus intufi A. Sm.

2 from Gobabis, 15 from Sandfontein, and 1 from Karolinenhof.

6. Crocidura deserti Schw.

♂. 2093, 2219, 2266. ♀. 2308, 2345. Sandfontein.

♀. 2385. Karolinenhof.

This beautiful silvery grey Shrew was discovered by Mr. Woosnam at Molopo in 1904, and described by Mr. Schwann in his account of the Kalahari collection.

No. 2385 is a slightly darker grey than the rest, but this is probably due to immaturity.

7. FELIS PARDUS L.

♂. 2322. ♀. 2274 (yg.). Sandfontein.
1939. Separate skull. Babi Babi, E. of Gobabis.

8. FELIS OCREATA XANTHELLA Thos.

♂. 2334. ♀. 2102. Sandfontein.
♂. 2390. ♀. 2405. Karolinenhof.

9. FELIS NIGRIPES Burch.

2556 (no skull). Gobabis.

10. CARACAL CARACAL DAMARENSIS Rob.

♂. 1878. Stampriet.
♂. 2000, 2039. ♀. 2191. Sandfontein.
♀. 2582. Witvley, W. of Gobabis.

This is no doubt the form called "*Lynx*" (*sic*) *caracal damarensis* by Roberts, and on the geographical probabilities of the case I am content to use the name, even though these specimens are very similar to some from Abyssinia and the Sudan, representing *nubicus*, the name I have previously used.

Roberts's *L. c. roothi*, published in September 1926, is no doubt my *Caracal c. coloniæ*, published in April of the same year.

11. ACINONYX JUBATA Erxl.

♀. 1570 (young), 2557 (skull only). Gobabis

12. GENETTA FELINA Thunb.

♂. 1779. ♀. 1730. Gobabis.
♀. 1860. Stampriet.
♀ & 3 young. 2238, 2335–7. Sandfontein.
Native skins. 2546, 2547, 2548. Oas.

13. HERPESTES CAUUI CALDATUS, subsp. n.

♂. 1682, 1708. ♀. 1674. Gobabis.
♂. 1889, 1928. Stampriet.
♂. 2275. Sandfontein.
2537–8 (unsexed). Oas, E. of Gobabis.

A warmer coloured race of the Rhodesian and Transvaal *cauui*. Size and general appearance as in *cauui*, a Museum specimen of which from Essexvale, Matabili Land, collected by F. C. Selous, has been carefully compared with the type in the Liverpool Museum, and so nearly matches that animal that it may be treated as typical. General colour above about as in that specimen, paler and deeper buff than the Zululand and Natal specimens representing *punctulatus* Gray. But the head and

neck are more ochraceous, the limbs are a richer buffy, and on the tail the rich ochraceous is more extensive, its extent on the upper side about equalling that on the lower side in *cauui*, while on the lower side it extends much further proximally, in most cases quite to the anus. In both it is deeper and more reddish ochraceous terminally than proximally.

Dimensions of the type:—

Head and body 310 mm.; tail 275; hind foot 56; ear 25.

Skull: greatest length, from crest 65·5; condylo-basal length 63; zygomatic breadth 33·6.

Hab. as above. Type from Sandfontein.

Type. Adult male. B.M. No. 26.12.7.42. Original number 2275. Collected 21 November, 1925.

This western race of the common *H. cauui* is more reddish than the eastern races of Rhodesia, the Transvaal and Natal, the difference in the body colour being slight, and rather of an average nature, but that in the tail more marked, and quite constant in all the specimens examined. The Mongoose described in the previous paper as *H. cauui swalius* is a very different animal, completely grizzled grey.

"Resembles *ratlamuchi* in being almost invariably found among or near the tree-belts that fringe dry water-courses. Similarly to a certain extent arboreal, but often to be found among rocks, when in the vicinity of tree areas. Shy and not particularly numerous, but conspicuous owing to their bright colour and diurnal habits. Going about singly or in pairs. Birds are inclined to mob this species, although they apparently take little notice of *Suricata*, *Mungos*, etc."—G. C. S.

14. CYNICTIS BRADFIELDI Rob.

♂. 2369. ♀. 2194, 2216. Sandfontein.

These specimens no doubt represent true *bradfieldi*, which was described from Okahandja, just to the north-west of Windhoek.

But comparison with them shows that the Ovamboland examples referred in the last paper to *bradfieldi* are decidedly lighter, and should be subspecifically separated.

Cynictis bradfieldi cinderella, subsp. n.

Size and general characters as in typical *bradfieldi*, but colour paler and more silvery, the nape and fore back quite silvery whitish. Back with the buffy much less intense, a more whitish buffy. Under surface lighter, the front of the thighs white. Hands and feet also decidedly lighter, almost white. Tail hairs with white instead of buffy tips, and the centre line of the tail below uniformly white.

Dimensions of the type:—

Head and body 325 mm.; tail 233; hind foot 67; ear 30.

Skull: greatest length 64; condylo-basal length 62; zygomatic breadth 36; mastoid breadth 28; bulla 17.

Hab. Ondongwa, Central Ovamboland. 3525′.

Type. Adult male. B.M. No. 25.12.4.40. Original number 1479. Collected 26 October, 1924.

"Occurring everywhere—although in some localities sparingly, between Windhoek and the Bechuanaland border. Diurnal, living in warrens, but more active and perhaps wandering further afield than *Suricata*, from which it differs in seldom sitting up, being quite like a typical mongoose in most of its movements."—G. C. S.

15. Mungos mungo grisonax Thos.

♂. 1633. ♀. 1612. Gobabis.
♂. 1835, 2459 (young). ♀. 1900, 2483 (young). Stampriet.
♂. 2225. ♀. 2243, 2244, 2270, 2279. Sandfontein.
2542–5 (unsexed). Oas, 32 mi. E. of Gobabis.

A valuable series of this pale race of the Banded Mongoose.

"Partly diurnal, although generally observed to be most active in the vicinity of their hiding places at about sundown. Plentiful in the neighbourhood of rocky tree-fringed water-courses. Highly gregarious, occasionally being met with travelling along river-beds in closely formed packs of 20 or more. At Stampriet a particularly large colony lived among the crevices of an old stone weir that spanned a dry stream. They do not possess the habit of sitting up like *Suricata*, although resembling that animal in being largely insectivorous and constantly digging with their fore-feet for grubs, beetles, etc. Whether on the move or in hiding, they are very noisy, and their presence may frequently be detected by their incessant grunting and chattering. Local Dutch name, 'Stink meerkat.'"—G. C. S.

16. Suricata suricatta hahni, subsp. n.

♂. 1620. ♀. 1602, 1619. Gobabis.
♂. 2072, 2073, 2193, 2370. ♀. 2068, 2272. Sandfontein.
♂. 2539. ♀. 2540. Oas, 32 mi. E. of Gobabis. 4800′.

A very pale Suricate, corresponding in general colour to the local *Cynictis, C. bradfieldi.*

General tone above pale buffy, not unlike that of *Cynictis bradfieldi*; considerably paler than in other forms of the Suricate. Sides of head nearly white, the dark eyerings and black ears standing out in strong contrast with the ground colour; a line along sides of crown behind ear also buffy whitish, as are the sides of the neck. Nape and fore back paler buffy; hind back with the usual dark markings, but less dark than in other forms. Sides broadly buffy yellowish. Under surface thinly haired, glossy whitish, the hairs with slaty bases. Limbs buffy whitish, the feet whiter than the more buffy thighs. Tail long, longer than in allied subspecies, slender, thinly haired, grizzled buffy, with only about a third black at the tip.

Skull about as large as in *hamiltoni*, a little smaller than in *suricata* and larger than in *namaquensis*, but without special distinctive characters. The muzzle not so lengthened as in the southern forms.

Dimensions of the type:—

Head and body 305 mm.; tail 240; hind foot 65; ear 18.

Skull: greatest length 67·5; condylo-basal length 63; zygomatic breadth 44·5; intertemporal breadth 21·3; mastoid breadth 36·4; palatal length 36; maxillary tooth-row 24·5; breadth between outer crowns of p^4 22; greatest diameter of m^1 6·7.

Hab. as above. Type from Gobabis. 4650′.

Type. Adult male. B.M. No. 26.12.7.53. Original number 1620. Collected 13 September, 1925.

By its very pale colour and short-haired tail this Suricate differs conspicuously from all the more or less greyish or brownish forms found in the Cape Colony from Little Namaqualand to Natal, but it is more nearly approached by the subspecies *hamiltoni* of the northern Orange River Colony and southern Transvaal.

One specimen, No. 2072, has an atavistic m^3 present on each side of the upper jaw.

It is a curious fact that in well-banded specimens of the longer haired southern forms of this genus, the bands may be distinctly *felt* on stroking the fur backwards, the black bands being concave and the white ones convex. This would appear to be due to the fur being so set in rows that the white bands have a greater length and thickness of fur than the black ones, and include a larger number, perhaps all, of the black-tipped hairs, which, lying backwards and surpassing the white hairs, increase the intensity of the black bands of the succeeding row. This phenomenon does not occur in the ordinary Banded Mongoose (*Mungos*) where the fur is of quite uniform length, the bands being produced wholly by the colour-rings on the individual hairs.

"Widely distributed, and in favorable localities plentiful, between Windhoek and the Bechuanaland border. Diurnal. These 'Meerkats' seem seldom to wander very far from their warrens. Owing to this and their similar habit of sitting up and remaining motionless, *Suricata* is far more often confused with *Geosciurus* by Colonists than with *Cynictis*; even natives frequently refer to them under one name. The burrows of all three are impossible to distinguish, and there is little doubt that they at times either share warrens, or make common use of deserted ones. Less widely distributed in S.W. Africa than *Cynictis*, being local or absent in Great Namaqualand, although in the central districts extending as far west as Rehoboth and Karibib. Apparently not penetrating far into the more wooded country of Northern Damaraland."—G. C. S.

17. HYÆNA BRUNNEA Thunb.

♀. 2380, 2214 (skull only). Sandfontein.
2530 (skull). Oas.
2550, 2551, 2552, 2553 (skulls). Gobabis.

"Unusually plentiful in Gobabis district. Unlike *Crocuta*, *H. brunnea* is a comparatively silent animal. The Brown Hyæna is generally locally considered to do next to no damage among stock. The only charges I have heard of brought against it, being of very occasionally devouring quite recently born lambs, and still more rarely to have the curious habit of biting off the tails of cattle at night, when they are lying down. I was shown several oxen with parts of their tails missing which was said to have been taken off by hyænas. Otherwise they are essentially scavengers, living on carrion and offal of all descriptions. They are easily trapped and are in a small way disliked for their habit of getting into leopard traps, which, if given time, they nearly always manage to smash with their jaws.

Around Oas at least half a dozen are said to be caught in traps to every one leopard. They are comparatively slow and clumsy in their movements and when attacked by dogs put up very little fight, their efforts being chiefly concentrated in trying to get away. If put up at dusk, it is astonishing how similar their general appearance is to that of a wart-hog. In South-West Africa and British Bechuanaland, except perhaps in the extreme north, they are everywhere far more plentiful than *Crocuta*. Extending at least as far North as the Zambesi and across the Cunene into Southern Angola."—G. C. S.

[CROCUTA CROCUTA Erxl.

"Evidently very rare in Gobabis district and considered like the lion to be an occasional migrant from the North and North-East. Two local skins only were seen, one from Epukire, and the other from the neighbourhood of Oas. In British Bechuanaland said to become comparatively plentiful towards Lake Ngami, where they are accused of being rather destructive to stock, especially among weak or young animals. Also reported to occur occasionally in the Northern Kalahari. Unlike *brunnea* they are particularly noisy animals, so that wherever they exist they are well known.

In Ovamboland and around the Etosha Pan, *Crocuta* may become the more plentiful species, being frequently heard at night in both of these areas."—G. C. S.]

18. PROTELES CRISTATUS Sparrm.

♂. 2260. ♀. 2258, 2259 (all young). Sandfontein.
Native skins. Babi Babi and Oas, East of Gobabis.

"Comparatively plentiful in Gobabis district. Recognized locally to be quite harmless to stock. Apparently prey largely

on insects, particularly white ants; and also no doubt to a smaller extent on small rodents, and eggs of ground-nesting birds.

A litter consisting of three cubs was dug out of a burrow near Sandfontein."—G. C. S.

19. Thos mesomelas arenarum Thos.

♂. 1769. Gobabis.

♀. 1836, 1920, 1925. Stampriet.

♂. 1984, 2261 (young). ♀. 2031, 2170, 2223. Sandfontein.

A fine series showing the general pallor of the S.W. African specimens as compared with those of the Cape Colony; the latter well represented in the Museum by specimens from Deelfontein.

"In Gobabis district, which is the most important stock raising district in the Protectorate, all farmers conversed with agreed that Jackals, although unusually plentiful, are not the serious menace to stock that they are in the Union: this is—without doubt correctly—ascribed to the amount of natural food they get in the way of small wild game."—G. C. S.

20. Vulpes chama A. Sm.

♂. 2328. ♀. 2316, 2323, 2333. Sandfontein.

"Comparatively plentiful in the Gobabis district, particularly in the 'Sand-veldt' country towards the Kalahari and Bechuanaland borders.

As with *Otocyon*, their food is locally realized to consist almost entirely of small rodents, lizards, insects, and occasional young birds. The 'bark' of a Silver Fox is rather similar to, but much weaker than that of an European Fox. When in winter coat, this fox is considered to have the best fur of any South African animal."—G. C. S.

21. Otocyon megalotis steinhardti Zuk.

♂. 2190—fully adult, and four young specimens 2262–5. Sandfontein.

Distinguished by its greater size from true *megalotis*. The present skull is even larger than the original, measuring—greatest length 134 mm.; condylo-basal length 129·5; zygomatic breadth 72.

The type came from Outjo, N.W. Damaraland.

"Fairly plentiful in the country travelled through, probably more so than *Vulpes chama*, and said to become still more numerous towards the South-East, where conditions resemble the Kalahari. Frequently going about in small packs or family parties.

Believed to feed almost entirely on small rodents and insects such as locusts and white ants. In Southern Ovamboland,

however, like *Proteles*, they are reported occasionally to be attracted by carrion.

Although not noisy animals like jackals, they have a distinctive call that is not infrequently heard at night in localities where they are common. At Sandfontein a litter of four cubs was dug out of a burrow."—G. C. S.

22. Lycaon pictus Temm.

2529. Skull only. Oas.

"The occasional migratory visits of packs of 'wild dogs' in Gobabis district are, as elsewhere, said to be accompanied by more destruction to stock and large game than in the case of all of the other Carnivora put together, owing to their well-known habit of destroying far more than they consume."—G. C. S.

23. Ictonyx striata Perry.

♂. 1596, 1692. Gobabis.
♂. 2101, 2224, 2226. ♀. 2276. Sandfontein.
♂. 2382. Karolinenhof.
Native skin. Oas.

These specimens, all obviously of the same species, cover in their variation nearly all the characteristics on which Mr. Austin Roberts has based half a dozen "new" species and subspecies. To suppose valid such characters as "underfur scanty"—in a midsummer specimen—or "dorsal stripes white instead of buff," in animals whose fur is known to vary widely in this respect, is to show a want of appreciation of mammal characteristics that is very unfortunate in so prolific a describer. Nor does he sufficiently realize the rarity, if not impossibility, of two closely allied species of identical habits occurring in the same place.

As to size, in the present series the condylo-basal length in adult males varies from 61 to 67·2 mm., the only female having this dimension 55 mm.

"Plentiful in Gobabis district as elsewhere in South-West Africa. Although normally preying on small rodents, 'Muishonds' when occurring close to habitations frequently become persistent poultry thieves, though they are easily trapped. They often take up their abode in the roofs or floors of outhouses. Even if caught when almost full-grown, this animal is readily tamed. Its offensive smell, although similar, is not be be compared in strength with that of an American Skunk, or of the Javanese *Mydaus*, not being powerful enough to keep off a dog."—G. C. S.

24. Mellivora ratel Sparrm.

1940. Babi Babi, 52 mi. E. of Gobabis.

"Well-known in Gobabis district, apparently occurring in rocky localities. On account of their strictly nocturnal habits, Ratels are seldom seen, although widely distributed and probably in

many places fairly numerous. Omnivorous. Their habit of feeding on wild honey is well known, and bees' nests that have been broken into by them are quite frequently met with. They are also believed to be great snake destroyers. Occasionally accused of raiding fowl-houses. During the breeding season they are said to become extraordinarily fearless and savage, and have been known to attack such large animals as cattle and horses that happen to have wandered too close to their hiding places."—G. C. S.

25. Geosciurus capensis namaquensis Licht.

25 from Gobabis, Stampriet, Sandfontein, and Oas.

"Diurnal, but during the hot weather coming out chiefly in the early mornings and late afternoons. Plentiful everywhere between Windhoek and the Bechuanaland border; more so than either of the Meerkats that they superficially so much resemble. This 'ground squirrel' has perhaps a somewhat wider range in South-West Africa than *Suricata*. Although extending into the Kaokoveldt, the South African Museum having recently acquired an example from near Gauko-Otavi, it apparently does not occur in Ovamboland or anywhere along the coastal 'Namib' belt. Comparatively scarce in the central parts of Great Namaqualand. During the hot season their coats become very thin and ragged, the long hairs of the tail frequently falling out before new ones have started to grow.

For its size *Geosciurus* has a very thick skin and is unusually muscular; it is also quite pugnaciously savage and with little doubt can hold its own with the 'meerkats' that it must come in constant contact with."—G. C. S.

26 Claviglis woosnami Dollm.

♀. 1686. Gobabis.
♂. 1890, 1891. Stampriet.
♀. 2092. Sandfontein.

The type was obtained by Woosnam at Okwa, in the Kalahari, about 200 miles east of Sandfontein.

No. 2092 is a very old specimen, with much worn teeth, and shows certain peculiarities which may or may not be due to its age. For the present, however, I assign it to the same species as the others.

C. woosnami is no doubt very closely allied to *C. griselda* Schwann, from Kuruman, and may hereafter prove to grade into it. But it is more desert-coloured and may provisionally be kept distinct.

"Well known to settlers along the Black Nosob River, but considered to be rather scarce. Apparently chiefly occurring in, or near the tree-belts that fringe river-beds. Although these particular specimens were discovered in hollow trees, there was plenty of rocky country in the close vicinity.

At Berseba, in Great Namaqualand, the local Hottentots spoke of a tree dormouse in addition to the local rock species, that was said to inhabit the tree-belt along the Fish River."—G. C. S.

27. Taterona schinzi Noack.

33 from Gobabis, 29 Stampriet, 79 Sandfontein, and 6 Karolinenhof, 147 in all.

This splendid series shows that in this region at least the tail coloration is of no value as a diagnostic character, for it varies in the same locality from bicolor, blackish above and white below, with a distinct black terminal tuft, to dull whitish proximally and wholly white terminally. The great majority of the specimens are more or less intermediate between the two extremes, and it is quite impossible to draw a line between them.

In common with other naturalists I have used this character as a distinguishing mark of species and subspecies of Gerbils, but now see that it should be regarded with great suspicion so far as that purpose is concerned.

"Extremely plentiful everywhere in Gobabis district, being found in both open localities and among tree-belts, although perhaps less numerous in the more open sand-veldt country that is preferred by *Gerbillus*. Their warrens, which are always conspicuous, are inclined to be rather more scattered than those of *Gerbillus*.

Apparently scarce or absent around Windhoek, but on proceeding east they commence to appear as soon as the country opens out sufficiently. To the south of Windhoek, like *Cryptomys*, *Suricata*, etc., they probably extend further west in the neighbourhood of Rehoboth, where conditions are more similar to those of Gobabis district, not seeming however to range south into Central or Western Namaqualand."—G. C. S.

28. Gerbillus swalius T. & H.

25 from Gobabis, 2 (in al.) from Dabris, 1 from Stampriet, 36 from Sandfontein, 1 from Karolinenhof, and 1 from Witvley.

In the previous paper a series of Gerbils from Ovamboland was referred to this species, but Capt. Shortridge has drawn my attention to the fact that they differ from true *swalius* of Karibib by their lighter colour. On comparison of all the material available I find he is quite correct, and the Ovambo Gerbil should be distinguished subspecifically.

Gerbillus swalius leucanthus, subsp. n.

General colour above inconspicuously lighter than in *swalius*, but the white of the under surface encroaching much more on the sides of the head and shoulders. Cheeks almost wholly white, with scarcely any trace of buffy below eyes and ears, the white also extending to the top of the muzzle, round the eyes, and on

and behind the ears. Tail also whiter, often with no buffy at all on its upper surface, but the usual dark terminal crest present.

Dimensions of the type:—

Head and body 102 mm.; tail 114; hind foot 26; ear 16·5.

Skull: greatest length 29·5; condylo-incisive length 25·7; bulla 8·7.

Hab. N.W. Ovamboland. Type from Ondongwa. 3525′.

Type. Adult male. B.M. No. 25.12.4.114. Original number 1527. Collected 3 November, 1924.

The further extension of the snowy white of the under surface on to the cheeks, muzzle, ear region, and tail render this Ovambo gerbil a particularly beautiful little animal.

Curiously enough while 12 specimens from northern and north-western Ovamboland all closely agree in the extent of the white, two specimens from Osohama, Etosha Pan, further to the south-east, are coloured like the ordinary *swalius* of Karibib. Their less hairy feet, and both shorter and shorter-haired tails suggest the *G. calidus* of the Kalahari, with which connecting links may hereafter be found.

"Very plentiful, chiefly concentrating in open sand-veldt country, where they make conspicuous small warrens that are easily identified by the sand thrown up outside each burrow, which, except for being smaller in size, much resemble those of *Taterona*. These warrens were nearly always more or less in the open and seldom concealed by tufts of grass or bushes as they seemed to be around Berseba."—G. C. S.

29. Desmodillus auricularis pudicus Dollm.

7 from Gobabis, 9 from Stampriet, 7 from Sandfontein, and 32 from Karolinenhof.

I may take this opportunity to select from the three cotypes in the British Museum, the female B.M. No. 43.2.28.17 as a lectotype of Smith's *Gerbillus auricularis*. Typical locality, Kamiesberg, Little Namaqualand.

"The burrows of this species are identical in appearance with those of *Saccostomus*, and they very frequently live together wherever patches of bare sandy country occur.

Desmodillus feeds to a certain extent on orthopterous insects, being particularly fond of locusts."—G. C. S.

30. Steatomys swalius umbratus Thos.

♀. 2161, 2330. Sandfontein.

The darker coloured *umbratus* would seem to be of wider distribution than the white-tailed true *swalius*.

Local or scarce in Gobabis district.

31. Saccostomus anderssoni de Wint.

2 from Gobabis, 12 from Stampriet, 13 from Sandfontein, and 2 from Karolinenhof.

There are unfortunately no very young specimens in this series, for comparison with the corresponding ages of *S. hildæ* and *pagei*. One half-grown specimen, however, No. 2442, is darker than the adults, not lighter as it is in *S. pagei*.

"About as plentiful as *Desmodillus* in this district, and frequenting similar patches of bare sandy country, where the burrows of both animals, which are identical in appearance, are conspicuous and easily found. Although in favourable localities there may be plenty of these burrows scattered about, they never form true warrens like *Taterona* or *Gerbillus*. Each burrow usually has two entrances, the emergency outlet being more or less perpendicular. Their cheek-pouches, which when fully extended are about the size and shape of silkworm cocoons, frequently contain insects (grasshoppers, white ants, etc.), as well as seeds; on one occasion they were found to be entirely filled with locusts' eggs.

All small rodents in South-West Africa feed very largely on the seeds of various species of acacia. The eyes of *Saccostomus* are small and—especially when the pouches are extended—have the appearance of being placed close together and far forward. Mammæ $4-2=12$."—G. C. S.

32. Thallomys damarensis de Wint.

21 from Gobabis and 31 from Stampriet.

A valuable series of these interesting Bushrats. The specimens show very little variation and agree well with the examples from Berseba which I took as representing *damarensis*, the exact locality of the type not being known.

"Particularly plentiful in Gobabis district, but confined to the tree-belts that fringe the Nosob and its tributaries. As elsewhere, appearing among the branches of trees soon after sunset. Very shy and active, disappearing at the slightest movement. In this district these squirrel-like tree-rats were quite frequently caught in traps set on the ground in the vicinity of their haunts. Hiding by day in hollow branches, the main entrances of which are generally, although not invariably, protected by large entanglements of sticks, there are, however always one or more escape holes higher up. In addition to protecting the entrances of their hiding places, they have a habit of making untidy nest-like structures among the branches, in which however I have never found them lying up by day; these may be playgrounds, or an additional means of escape from *Herpestes* or owls, which last are unusually numerous in these tree-belts. During life the ears of *Thallomys* stand out from the head at a similar angle to those of a dormouse. In a large hollow tree there will often be a small colony, most of whose occupants however are in various stages of immaturity. A very young specimen was found on the ground near a trapped female, so that they may have the habit common to many tree-rats of occasionally carrying their young about attached to their mammæ."—G. C. S.

33. LEMNISCOMYS GRISELDA SABULATA, subsp. n.

♂. 2103. Sandfontein. B.M. No. 26.12.7.195. 10 November, 1925. *Type*.

Nearly allied to the *L. griselda griselda* of Angola, but the general colour above much paler, of the greyish-buffy tone so characteristic of many of the South-West African mammals. General colour of head and back near "pinkish-buff"; tendency to whiter spotting more perceptible than in *griselda*, slightly more so than in *linulus*. Rump and base of tail buffy, not ochraceous. Underside pure white. Lines above and below eyes buffy whitish. Ears as usual more buffy than the head, but not the deep ochraceous found in *griselda* and most of the other forms; hairs at their base buffy, on the postanal patch white. Hands and feet pale buffy-whitish. Tail dark above, buffy laterally and white below.

Skull without special characteristics.

Dimensions of the type:—

Head and body 114 mm.; tail 123; hind foot 26; ear 15.

Skull: greatest length 30; condylo-incisive length 27; nasals 10; interorbital breadth 4; palatal foramina 8; upper molar series 6.

This representative of what used to be known as the "*dorsalis*" group differs from its nearest ally, the Angolan *griselda*, by its much paler coloration throughout, in conformity with the usual pallor of Ovambo and Damaraland Mammals.

It is in fact most like *L linulus* of the Gambia, but is even paler than that is, not having the latter's ochraceous ears and base of tail, while the light spotting on the flanks is more white, less buffy.

It may be a convenience to S. African workers if I recapitulate the reasons for the use of the specific name *griselda*.

For over 70 years, 1845–1916, the S. African single-striped mouse was known by Smith's name of *dorsalis*, but in the latter year I had to point out that the name *Mus dorsalis* was invalidated by G. Fischer's *Mus dorsalis* of 1814, and I replaced *dorsalis* by *spinalis*. But since several subspecific names had already been attached to *dorsalis*, the earliest of these, *griselda* (1904), takes precedence of *spinalis* (1916) and becomes the specific name for all. To this is then attached *rosalia*, *pharotis*, *calidior*, *spinalis*, and such other subspecific names as there may be, *sabulata* being now added to them.

Smith's *Mus dorsalis*, and consequently my *spinalis*, having been based on several co-types, all now in the Museum, it will be advisable to select a lectotype for the name. This might be B.M. No. 45.7.3.23, an adult male, acquired from Sir Andrew Smith in 1845.

The close resemblance that *Lemniscomys g. sabulata* from S.W. Africa bears to *linulus* from the Gambia, like the similar resemblance of *Mungos mungo grisonax* to *M. talboti* of Bornu,

brings us again face to face with the problem as to what should be done taxonomically with animals from widely different localities which are to our eyes indistinguishable, but which from the intervening occurrence of different forms and other evidence we are quite sure have been developed independently. The phenomena of desert coloration and saturation are the two most frequent and most obvious of these cases, and the problem as to how to treat them has to a great extent been shirked by systematic mammalogists. If we are to try to get our taxonomic arrangement and nomenclature to give some sort of idea as to the course of evolution in the different animals—and this should be our ideal—we must I believe take the bold step of recognizing animals as distinct if of obviously separate and independent origin, even if to our eyes they look quite the same. We should thus be recognizing the locality as an essential part of the animal's individuality, and this I believe to be the true way out of the difficulty.

To give for example the same subspecific name to the forms inhabiting widely separated deserts when they are independent modifications of a common type appears to me to result in an amorphous jumble in which all trace of connection between the course of evolution and the nomenclature is lost.

I should therefore not hesitate to accept names for animals of independent origin even if the actual specimens were indisguishable.

Of course, like everything else, this principle might be carried to an absurd extent, but if the characters were sufficient to render valid the distinction of one form, they might equally authorise the distinction of two.

No doubt the phenomenon is exceedingly rare, for some character would generally be found to distinguish independently developed forms, but its possibility must be admitted, and we should not be afraid to face it.

It does not occur in the present animal, as although very like the W. African *linulus* group of *Lemniscomys*, *L. g. sabulata* is quite distinguishable from any of them.

"Apparently scarce, a single specimen was trapped in open bush country at Sandfontein close to the Bechuanaland border. The skin of this species differs from that of *Rhabdomys* in being white inside instead of slate-black."—G. C. S.

34. Rhabdomys pumilio griquæ Wr.

25 from Gobabis, 4 from Stampriet, 1 from Grunerfeld, 2 from Sandfontein, and 1 from Karolinenhof

This fine series shows the extent of the variation in colour occurring in the group, some of the specimens being as pale as the type of *deserti* and others closely matching that of *griquæ*, which latter name should I think be used for all. As noted in 1925 the lowland specimens from the coast (Rooibank etc.) are

decidedly larger than the plateau forms, they have larger bullæ, and should undoubtedly bear the name *bechuanæ*, with whose type they are absolutely identical. Roberts's *R. p. namibensis* from Swakopmund is evidently the same form.

"Diurnal. Plentiful near Gobabis Town, in the vicinity of the Black Nosob, but not trapped in large numbers anywhere further east.

Differing from the semi-arboreal race trapped around Berseba in the average tail-length being less than that of the head and body."—G. C. S.

35. ÆTHOMYS CHRYSOPHILUS IMAGO, subsp. n.

7 from Gobabis, 3 from Oas, 12 from Stampriet, and 12 from Sandfontein. And 5 in spirit.

A very pale race of *Æ. chrysophilus*, the general colour averaging far paler than in any of the races from eastern S. Africa. Colour above pale buffy, lined with brown on the back, clear pale buffy on sides. Under surface white, a variable amount of the hairs with slaty bases. Feet of average normal length, not lengthened as in *acticola*.

Skull as in true *chrysophilus*, not narrowed and flattened as in *ineptus*.

Dimensions of the type:—

Head and body 147 mm.; tail 174; hind foot 29 (more generally 28); ear 20.

Skull: greatest length 36; condylo-incisive length 33·5; upper molar series 6.

Hab. S.W. Africa; type from Stampriet.

Type. Old male. B M. No. 26.12.7.220. Original number 1832. Collected 14 October, 1925.

This is an exceedingly pale form of the plastic *Æ. chrysophilus* and is readily distinguishable by colour from any of the subspecies described from eastern S. Africa, the Transvaal and elsewhere. It is, however, not unlike the form described by Kershaw as *Æ. c. singidæ* from the desert region of the Tanganyika Territory, but even that averages darker, although the type happens to be a particularly pale specimen. In any case on the principles given above under *Lemniscomys* I do not consider that this animal from the south-western desert should bear the same subspecific name as that found in a quite distant desert area, separated by the Tanganyika, Congo Forest, Nyasan and Rhodesian regions, all of which have, or may be presumed to have, comparatively dark-coloured representatives of *Æ. chrysophilus*. A representative specimen from the Nyika plateau, Northern Nyasa, on the only possible route between the two regions now concerned, is absolutely of the same dark general colour as those that come from the Transvaal.

In view of the rarity of sexual distinctions among rodents, it is worthy of mention that the males of *Æ. chrysophilus* commonly

develop much thicker and heavier supraorbital ridges than the females.

"Comparatively plentiful and widely distributed in Gobabis district.

A bush rat, chiefly frequenting patches of thick undergrowth, in the vicinity of the tree-belts that fringe dry water-courses. The bushes among which their burrows occur are occasionally topped with rain or sun shelters of dry grass that are, however, quite unlike the elaborate structures made by *Æthomys namaquensis* or *Parotomys*."—G. C. S.

36. Æthomys namaquensis calarius Thos.

31 from Gobabis, 37 from Stampriet, 30 from Sandfontein, and 3 from Witvley, 101 in all.

This fine series confirms the average distinction of the Cunene *siccatus* from the Kalahari *calarius* by its longer tail, for while the ten longest-tailed examples of the present series have an average tail-length of only 150 mm., the eight adult specimens of *siccatus* in the Cunene collection average 168 mm. in this dimension. Both forms are characterized by their pure white bellies.

"Extremely plentiful, especially in rocky country; but in this district towards the Bechuanaland border, possibly owing to their having overcrowded the localities that they normally prefer, they have spread into many parts of the open sand-veldt, where, as there are no suitable hiding places, they make conspicuous domed nests of unusual size—generally in the middle of a bush—of sticks and grass, even the nests of Weaver-birds being occasionally dragged into use. These structures, which are built over underground burrows, are rather similar to those of *Parotomys*, but much larger, a large one measuring up to 4 feet in diameter and from 2–3 feet in height. They are very inflammable and must often be destroyed by bush fires, on which occasions, however, the occupants would escape below ground. In addition to their normal inhabitants, stray *Mastomys* are not infrequently found in these nests.

In rocky situations, as in Damaraland etc., they live normally in rock crevices, merely closing up the outlets with a few handfuls of sticks and grass."—G. C. S.

37. Ochromys woosnami Schw.

19 from Sandfontein, 1 from Gobabis, and 1 from Karolinenhof.

This remarkable white-tailed rat has been so well described by Schwann that I have little more to add.

The hairs of the underside are sometimes wholly white and sometimes have slaty bases, the difference often occurring in a patchy manner, as though the hairs of one season were slaty-based and of the other wholly white, a peculiarity I have never heard of in other mammals. In a general way there is a tendency

for the hairs of the throat and chest to be wholly white and those of the belly grey-based, but in changing specimens the patchiness of the arrangement is very peculiar.

The type was obtained on the Molopo River, and others again in Ngamiland.

"Widely distributed but apparently local in Gobabis district. Comparatively plentiful around Sandfontein although far outnumbered by *Taterona*, *Æthomys*, etc. Chiefly trapped among scattered bushes--away from trees—in the vicinity of dry watercourses. This species has a distinct musky smell, similar to that of a shrew mouse."—G. C. S.

38. Mastomys coucha bradfieldi Rob.

89 specimens from Gobabis, Stampriet, Sandfontein, and Karolinenhof.

A *Mastomys* with the general pallor characteristic of the mammals of the South-West African area. The type was described from Okahandja, but there seems no reason why a second subspecies (*M. c. ovamboensis*) should have been described from Namutoni, in the same general area. No valid distinguishing character is given, the two forms being separated by the different lengths of the tail, 96 and 111 mm. respectively, which are however well within the limits of normal variation—as exemplified by the present series.

"Plentiful—especially in the vicinity of dry water-courses or where bush vegetation happens to be thicker than usual. Apparently not much, if at all, in the habit of entering houses in this district."—G. C. S.

39. Leggada bella induta Thos.

♂ (old). Karolinenhof.

Of the several specimens sent home by Sir Andrew Smith as cotypes of his *Mus minutoides*, No. 7.1.1.217 may be selected as a lectotype. It is the one whose tail may be most nearly measured as $2\frac{1}{4}$ in. It came from the collection of Mr. Tomes, who had obtained it from the Zoological Society's Museum, in whose Catalogue it is entered as No. 697 "No. 21" (presumably of Smith).

"As elsewhere in South-West Africa, apparently comparatively scarce in the Gobabis district, although possibly widely distributed. Said occasionally to enter houses at Oas."—G. C. S.

40. Cryptomys lugardi de Wint.

20 from Sandfontein and 4 from Gobabis.

A very valuable series as indicating the range of variation found in a single locality within this most difficult genus. Externally all the skins are uniformly dark slaty and all have a frontal spot of variable size and shape. But the skulls differ

greatly among themselves in size and detailed characters, and give further evidence, if such were needed, that most of the absurd multitude of species and subspecies described by A. Roberts from eastern South Africa are absolutely untenable. Five further names are given in his 1926 paper.

"Very plentiful and widely distributed in Gobabis district, except in rocky areas. Extending west to within 20–25 miles of Windhoek. Its southern distribution in this district was not ascertained, but further west its range does not go further south than Rehoboth. Probably occurring everywhere throughout the flat sandy eastern parts of South-West Africa, northwards from about the tropic of Capricorn and beyond the border into British Bechuanaland to at least as far north and east as Lake Ngami. In the hill country of Central Damaraland to the west of the Railway its range becomes interrupted and local, coinciding with occasional stretches of flat sandy soil that extend here and there between mountain ranges. *Cryptomys* mounds were observed from the railway around Rehoboth, Eronge Siding, and in the vicinity of Kalkfield, Otjiwarongo, and Otavi Junction. They become again plentiful and evenly distributed in Ovamboland from the edge of the Etosha Pan, northwards.

If burrows of this species are opened by day they invariably sooner or later close them up, probably to guard against the entrance of snakes, which I imagine to be their chief enemies. Before doing so, they put their heads out for a few seconds and peer around—then they may be shot, or caught if a spade is put quickly behind them; they are however very wary and quick, darting back at the slightest sound or vibration from above, and rarely appearing a second time. Their eyes, although so extremely small, are prominent, and I believe them to be able to see for a short distance. Apparently seldom coming above ground of their own accord except perhaps during the breeding-season. They are savage when caught, and when placed above ground have a curious habit of walking backwards away from suspected danger. They are however fairly active and can travel almost as fast as a hedgehog. The attachment between the two branches of the lower jaw of mole rats is not osseous, so that the lower incisors have a slightly independent movement. The feet also (of *Cryptomys* particularly)—relatively with small claws—appear to possess less muscular power than is the case with most other mammals that are so entirely fossorial in their habits; this may account for their obvious preference for loose sandy country, and entire absence in the Western Karroo, Namaqualand, etc., where so much of the country is stony or rocky. Digging is no doubt done by the incisors, not by the feet. The mounds raised by mole rats are larger than those of insectivorous moles. The soil when first thrown up is bound together in sausage-shaped rolls, which however break up in a short time after exposure to the air. In addition to bulbs, apparently feeding on the roots of 'water grass' and other tuberous plants. Not seeming to be

attracted to the small amount of cultivation in this district—being said to do no damage to cultivation around Oas. The present series were all in 'dark fur,' but, as in Ovamboland, there is probably a similar (seasonal) change. The hot season is evidently not the breeding-season, as no fœtuses were found either in this district or in Ovamboland. It is difficult to ascertain during life when specimens are adult; quite small females frequently have well-developed mammæ, so that they probably breed before reaching maturity. Mammæ 2—1=6."—G. C. S.

41. PEDETES CAFER Pall.

19 from Gobabis, Stampriet, and Sandfontein.

"Extremely plentiful in Gobabis district. Nocturnal, seldom seen before dusk. The most abundant of the larger rodents, although, in rocky areas, approached in numbers by *Lepus saxatilis*. As in Ovamboland, 'spring-haas' are frequently caught, in this district chiefly by bushmen, by means of an iron wire hook attached to a flexible reed shaft from 15–20 inches in length, which is twisted into their burrows. They are one of the staple articles of diet for the bushmen of this district. Their eyes, which are proportionally very large, are conspicuously luminous by night, on which account they can easily be recognized in the dark, as on account of the shape of their heads—unlike that of the Carnivora—only one eye can be seen at a time."—G. C. S.

[PETROMYS sp.

"Indications of *Petromys* were observed among rocks between Windhoek and Ondekaremba, so that it may extend as far east as the mountains around Omitara on the Windhoek-Gobabis border. It does not occur, however, among the low kopjes in the vicinity of Witvley or anywhere further east."—G. C. S.]

42. HYSTRIX AFRICÆ-AUSTRALIS Pet.

♂. 2188, 2343. ♀. 2185, 2189. Sandfontein.

"Apparently more than usually plentiful in rocky country around Sandfontein, as, judging by burrows, tracks, and shed quills seen, they are elsewhere in Gobabis district.

Nocturnal, occasionally put up on moonlight nights."—G. C. S.

43. LEPUS ZULUENSIS HERERO Thos.

♂. 1634, 1709, 1731. ♀. 1698, 1699, 1768. Gobabis.

♀. 2240, 2241 (yg.). Sandfontein.

♂. 2458, 2469, 2482, 2514. ♀. 1830, 1898, 2490. Stampriet.

The grouping of the South African hares of the genus *Lepus* is still in a very confused state, and it is by no means easy to say to what group such and such a form belongs, as there are almost no essential characters distinguishing the groups. Without at present attempting to make a real classification, it appears to me

that the "*saxatilis*-group" might be restricted to the forms with extra long ears, such as *saxatilis* itself, *orangiæ* and *megalotis*, the ears in these measuring about 130–150 mm. Then *zuluensis* and *herero* (the latter wrongly placed on description in the *capensis* group) might be considered as forming a second group, most allied to *saxatilis* and with similarly greyish coloration and grey feet, but with the ears only about 100 to 115 mm. in length. To that group the present animal belongs, agreeing very closely with *herero* from Ovamboland. Lastly, the *capensis* group, smaller, suffused with buffy, and, especially, with more or less rufous, buffy, or yellowish feet, contains *capensis*, *granti*, *ochropus*, and their allies.

The hare from Okahandja described by Mr. Roberts as *L. zuluensis damarensis* he has placed correctly in its group, but he has been unlucky enough to be a few months in date behind my *herero*, of which *damarensis* is clearly a synonym. The skull-length agrees exactly, and although the ear seems unusually long for the group, it is probable that he has measured it from the head instead of taking the standard measurement from the notch.

Of course, the remarkable little *L. monticularis* forms a group by itself, while I am still doubtful as to the true position of *L. narranus*.

"Extremely plentiful from Windhoek eastwards throughout Gobabis district, concentrating in rocky situations. In this district they are particularly numerous in tree-belts that fringe rocky water-courses. The *saxatilis*-group are by far the most numerous and widely distributed of the South African hares, being by no means confined to rocky country or high veldt, as has sometimes been stated. Like *Pedetes* they are easily shot at night by the help of a lantern, light dazzling them so much that they are frequently run over by cars. In many places they have rather a bad name, invading vegetable gardens and barking fruit and other young trees. The white frontal spot is always present although variable in size."—G. C. S.

44. Lepus capensis mandatus Thos.

♂. 2271. ♀. 2321. Sandfontein.
Young, 2559. Oas.

A very fair match with the Berseba hares; palpably different from those of Ovamboland.

"More local and far less plentiful than *L. saxatilis*, from which it differs in seldom being found away from open sand-veldt. In one instance a single individual was observed in undulating—slightly rocky—country near Ondekaremba, but as a rule appearing actually to avoid hilly or even stony localities. Rather shy and difficult to procure without dogs.

Lying up under low bushes and making off at full speed straight across country, when put up, at which time it is easy to

distinguish from *saxatilis*, being smaller and more rabbit-like, while its much shorter reddish legs are generally noticeable.

This species has occasionally a white spot on its forehead; but this is not such an invariable characteristic as in the case with *saxatilis*. 'Vlakhaas' were spoken of around Upington, Berseba, and in other localities, in addition to those from where examples were obtained, so that local races of this form are apparently widely distributed in the open sandy parts of South-West Africa."—G. C. S.

[PRONOLAGUS CRASSICAUDATUS Geoff.

"Plentiful around Windhoek, and without doubt occurring among the mountains in the vicinity of Omitara and possibly the kopjes near Witvley, but otherwise not occurring in Gobabis district."—G. C. S.]

45. PROCAVIA CAPENSIS WINDHUKI Brauer.

2563. Skull only. Witvley, W. of Gobabis.

"Plentiful on the hills that occur around Omitara and elsewhere on the western border, and also among the low isolated kopjes in the vicinity of Witvley. Reported to occur at Bavian's Kloof at the junction of the Black and White Nosob, otherwise not found in Gobabis district. Although normally diurnal, during the hot weather 'rock rabbits' seldom leave the vicinity of their hiding-places except in the early morning or just before sunset, and, like *Petromys*, *Elephantulus*, etc., occasionally stopping out well after sundown, especially when there is a moon."—G. C. S.

46. PHACOCHŒRUS ÆTHIOPICUS Pall.

♂. 1787. Grunfeld, 50 mi. E. of Gobabis.

♂. 1946, 2213 (skull). ♀. 2215. Sandfontein.

♀ (yg.). 2389. Karolinenhof.

♂. 2536 (skull). Oas.

"Quite plentiful in many parts of Gobabis district, especially in the vicinity of water-holes or vleis, where they lie up during the day in adjacent high grass or bush cover. As individuals appear to drink fairly regularly, it is difficult to know how the majority get on during a particularly dry season; on such occasions, being like other pigs—great rooters,—they presumably obtain a sufficient supply of moisture from bulbs and other succulent roots. Going about singly, in pairs or small 'sounders' that are probably as a rule family parties. Frequently observed visiting water-holes at dusk, or occasionally—where undisturbed—even during the heat of the day.

Said frequently to hide by day, or to take cover when hunted, in ant-bear holes. Although a wounded animal will charge if approached too closely, they are on the whole rather timid, and lack the aggressiveness of the Indian wild boar or even—from all accounts—the African Bush Pig.

The Bush Pig—*Choiropotamus*—does not occur in Gobabis district, although appearing further north in the heavier rainfall area from Tsumeb northwards."—G. C. S.

[EQUUS BURCHELLI Gray.

"Zebras do not exist in Gobabis district, although there is little doubt that they formerly did so.

Two Burchell's Zebras are said to have recently been observed near Reitfontein (North) on the British Bechuanaland border to the east of Epukiro. They are said to be widely distributed in the northern parts of British Bechuanaland, and to become plentiful between Ngamiland and the Caprivi.

Among large animals that are said formerly to have occurred in Gobabis district may be mentioned Elephant, Rhinoceros, and Buffalo."—G. C. S.]

[GIRAFFA CAMELOPARDALIS L.

"Giraffe are entirely extinct in Gobabis district. A solitary bull is said to have been killed by bushmen at Dabis, some miles west of Sandfontein, as recently as 1920; without doubt a stray specimen that had wandered down from Northern Bechuanaland. They are, however, still quite well known to the Auen and Naron bushmen, who are said formerly to have made their sandals from giraffe hide.

One hears on all sides that in British Bechuanaland giraffe are being rapidly exterminated by natives with guns—in spite of their nominal protection, and they now occur in yearly decreasing numbers chiefly between Lake Ngami and the Caprivi, very occasionally wandering south to about 100 miles of the north-eastern corner of this district."—G. C. S.]

47. BUBALIS CAAMA Cuv.

♂. 2513. ♀. 2475. Stampriet.
4 frontlets and horns.

"In South-West Africa the Cape Hartebeest occurs mainly in the north and east, being distributed along the Kalahari border and in Eastern and Northern Damaraland (the Etosha Pan area and Ovamboland), Extends just into Southern Angola. Apparently not occurring in the extreme north-east nor along the Caprivi; this agrees with its distribution in Northern Bechuanaland, according to Bryden, who states that just north of the Mababi River its range suddenly ceases. In Gobabis district it is comparatively plentiful, occurring chiefly in flat, open, or thinly-wooded sand-veldt. Eland, hartebeest, and wildebeest are to a certain extent migratory, especially in times of drought, and are said to be most numerous in Gobabis district between February and July. Hartebeest and perhaps wildebeest are

locally thought to be slightly on the decrease. The hartebeest shares with the eland, gemsbok, wildebeest, etc., the habit of resorting to salt pans by night."—G. C. S.

48. GORGON TAURINUS Burch.

♀. 2453. Karolinenhof.

"In South-West Africa the Blue Wildebeest has very much the same distribution as the Cape Hartebeest, except that towards the north in the Namutoni game reserve, Ovamboland etc., the former is by far the more plentiful. Extends into Angola—according to Bryden—to as far north as Benguella, and also towards the Okavango and along the Caprivi. In Gobabis district they are said to be among the first of the big game to feel a drought, when they become restless and concentrate into herds, occasionally of large size, subsequently migrating northwards, or in whatever direction more suitable grazing conditions may exist. Chiefly frequenting flat, open, sandy country, and although the appearance of large herds is irregular, they are generally considered to be individually plentiful."—G. C. S.

49. SYLVICAPRA GRIMMII, subsp.

♀ 2140 & ♂ fœtus 2160, ♀ 2237, ♀ 2284 & ♀ fœtus 2285, ♀ 2299 & ♀ fœtus 2298, ♀ 2343. Sandfontein.

♂. 2568. Omitara, 85 mi. W. of Gobabis.

I have no greater belief than before in the numerous races of the common Duiker described by Dr. Zukowsky from the Damara region.

Mr. Roberts again pays no attention to Zukowsky's paper, and describes three further new forms, one of them from Okahandja, in Damaraland itself.

"Very plentiful in Gobabis district. Except in the more open areas duiker and steinbok occur in about equal numbers. Duiker as a rule prefer fairly thick cover, and are particularly numerous in the vicinity of tree-belts, or wherever there are considerable patches of dense scrub. In South-West Africa duiker as well as steinbok appear to be quite independent of water. Move about singly or in pairs."—G. C. S.

[ÆPYCEROS MELAMPUS Pall.

"Impala have been extinct in Gobabis district for many years, but are said formerly to have existed in the vicinity of Gobabis town, to which locality they were probably attracted—as up to more recently near Omaruru—by small stretches of surface water in river-beds. Although before white settlement originally existing further east around the few permanent surface-water areas—at any rate as far south as Kuruman,—at the present time they seldom if ever wander south of the well-watered country between Lake Ngami and the Zambesi."—G. C. S.]

[OREOTRAGUS OREOTRAGUS Pall.

"The Klipspringer without doubt exists among the few rocky hills such as occur around Omitara etc., near the western boundary of Gobabis district. It does not however extend to the low kopjes in the vicinity of Witvley, nor the undulating rocky areas further east. Doubtfully reported from Bavian's Kloof at the junction of the Black and White Nosob rivers. Apparently reappearing in the rocky hills that occur near the eastern border of British Bechuanaland."—G. C. S.]

50. RAPHICERUS CAMPESTRIS Thunb.

♂. 2002, 2307 (both yg.). ♀. 2013, 2256. Sandfontein.

♀. 2391. Karolinenhof.

No fewer than four subspecific names for Steinbuck from this region have been given by Zukowsky and Strand, in spite of the general uniformity of the plateau fauna.

"Widely distributed and plentiful everywhere in Gobabis district. Lydekker ('Game Animals of Africa') records that steinbok are 'grass-feeders'; but this is not entirely the case, as they feed to quite a large extent on the leaves and berries of bushes, and I have frequently observed that they have the habit of standing on their hind-feet like goats in order to reach the foliage of bushes and low trees."—G. C. S.

51. ANTIDORCAS ANGOLENSIS HOFMEYRI Thos.

♂. 2381. ♀. 2368. Sandfontein.

♀. 2479, 2480, 2491: frontlets. Stampriet.

"Comparatively plentiful in Gobabis district, where they collect chiefly in more or less open sand-veldt country. Apparently becoming more evenly distributed further south towards the Kalahari. Generally numerous in British Bechuanaland, and according to some observers thought to be gradually extending their range northwards, although apparently not occurring beyond the latitude of Lake Ngami."—G. C. S.

52. TAUROTRAGUS ORYX Pall.

♀. 2501. Stampriet.

"Comparatively plentiful but local in Gobabis district, where they are generally considered to be—if anything—increasing in numbers. Said not to extend far south of the 23rd parallel, towards the southern limit of their range, apparently keeping more or less closely to tree-belts. In addition to being at all times more or less gregarious, they have the well-known habit locally—especially towards the north of this district—of collecting, at intervals, in herds of considerable size that occasionally amount to several hundred. These herds, that without doubt represent the periodical migratory concentrations of practically all that exist over a very wide area, are apt to give a misleading idea of

their normal numbers in any one locality. Chiefly frequenting the thinly-wooded parts of the sand-veldt, especially in the vicinity of dry river-beds, although at times they also visit rocky ridges, probably for the sake of a kind of sweet grass that is peculiar to that type of country. Like the Kudu they are apparently able to exist without water for considerable periods."—G. C. S.

53. Oryx gazella aschenborni Strand.

♂. 2476. ♀. 2500. Stampriet.

Approach the ordinary *O. gazella* in general colour more than did the specimen from S. Ovamboland mentioned in the previous paper. It is interesting to notice that in one example, the male, the white band extends unbroken across the face, while in the female the median black band cuts it in the centre. The former condition is supposed to be characteristic of *aschenborni* and the latter of *gazella*, but the difference between the two specimens confirms what was previously said as to the little value of such characters.

"Comparatively plentiful, although not so numerous in Gobabis district as wildebeest or hartebeest."—G. C. S.

54. Strepsiceros strepsiceros Pall.

♂. 1899. ♀. 1829. Stampriet.

"In Gobabis district, as elsewhere in South-West Africa, the Kudu is the most widely distributed of the larger antelopes, where, as usual, it is most plentiful in rocky bush-country. Generally goes about in twos or threes; occasionally—towards the end of the dry season—collecting in small herds of a dozen or more. During a particularly severe drought a local concentration—probably in migration—approaching 150 in number was reported to me, but this is without doubt of exceptionally rare occurrence."—G. C. S.

55. Orycteropus afer Pall.

♀. 2257 (immature—no skull). Sandfontein.

"Well known in Gobabis district, but apparently not very plentiful, although, as in the coastal or extremely mountainous areas, deserted burrows are frequently quite numerous. Ant-hills are particularly scarce in Gobabis district, and as already noted by Lydekker ('Game Animals of Africa'), the Aard Vark seems—in this part of the country—to prefer the white ants that, although living in the ground, throw up no mounds. This type of white ant is locally plentiful, as also are those that attack and live in decayed wood. At the same time, in Ovamboland and wherever else in South-West Africa typical ant-hills occur, ant-bear diggings may usually be found.

The skin is very firmly attached to the flesh, and the muscular strength of the animal is remarkable. Contrary to report, the meat is very poor eating."—G. C. S.

[MANIS TEMMINCKII Smuts.

"Widely distributed and well known in Gobabis district, but seldom seen, and considered to be scarce. Similar to *Orycteropus* in its burrowing and nocturnal habits. Not appearing to avoid even exceptionally rocky country."—G. C. S.]

24. Schewiakoff's Keys for the Determination of the Holotrichous Ciliates. Translated from the Russian by Cecil A. Hoare, B.Sc., Wellcome Bureau of Scientific Research, London *.

[Received March 30, 1927 : Read May 10, 1927.]

Schewiakoff's important monograph on 'The Organisation and Systematics of the Infusoria Aspirotricha' †, though written more than thirty years ago, still stands as the most valuable and complete contribution to the Order Holotricha as a whole. It has the practical advantage of being provided with carefully compiled dichotomous keys to the families, genera, and species of the Order.

Unfortunately, Schewiakoff's monograph was written and published in Russian and is thus not available to the majority of foreign zoologists. The following translation of the keys was undertaken with the object of bringing this part of the monograph within reach of English readers and at the same time providing a practical guide to the identification of these ciliates. Though undoubtedly out of date and incomplete in some parts, the keys will remain indispensable till the whole Order has been completely revised. At present, moreover, there is no other work which deals with all the holotrichous ciliates in a comprehensive manner.

An adaptation of Schewiakoff's monograph has been made by Schouteden ‡ in French, but the paper is very inaccessible. In the English translation given below care has been taken to conform to the original in all cases except when the author's definitions do not appear with sufficient clearness. The amendments made in such cases are based on his own descriptions and are introduced in square brackets.

Schewiakoff's object in producing the monograph was to continue and complete the work which had been commenced by Stein, who, in publishing the monographs on the Orders Hypotricha and Heterotricha (1858–1867), intended them to be parts of a complete work dealing with all the ciliates known at the time.

* Communicated by C. M. Wenyon, C.M.G., C.B.E., M.B., F.R.S., F.Z.S.

† Mém. Acad. Imp. Sci. St. Pétersbourg (VIIIe sér.), vol. iv. 1896 (pp. ix + 325 + 13; 7 plates).

‡ Schouteden, H. (1906), "Les Infusoires Aspirotriches d'eau douce," Ann. Biol. Lacustre, i. p. 383.

The classification of the Class Ciliata adopted by Schewiakoff is as follows:—

I. Order ASPIROTRICHA.
Sub Orders: Gymnostomata.
Trichostomata.
Astomata.

II. Order: SPIROTRICHA.
Sub-Orders: Heterotricha.
Oligotricha.
Hypotricha.
Peritricha.

Schewiakoff's Order Spirotricha corresponds with Bütschli's Sub-Order of the same name, whereas his Order Aspirotricha embraces Butschli's two Orders Gymnostomata and Trichostomata, and is equivalent to Stein's Order Holotricha, with the addition of some families formerly referred to the Orders Hypotricha (Erviliina and Chlamydodonta) and Peritricha (Cyclodinina).

Order ASPIROTRICHA.

Key to Families:

1. Cytostome present, sometimes visible only during ingestion 2.

1 *a*. Cytostome absent: parasitic forms. Sub-Order ASTOMATA . XIX. Fam OPALININA.

2. Cytostome usually closed, its margins not surrounded by special cilia. Pharynx—if present—naked, in many surrounded by rod-apparatus. Sub-Order GYMNOSTOMATA 3.

2 *a*. Cytostome permanently open, its outer margin bears a row of cilia or 1–2 undulating membranes. Pharynx—if present—covered with cilia, or with 1 2 rows of cilia along its wall, or bearing an undulating membrane. Sub-Order TRICHO-STOMATA . . . 12.

3. Cytostome at anterior end of body: A. PROTOSTOMATA . 4.

3 *a*. Cytostome slit-shaped (lateral) or circular (on ventral surface): B. PLEUROSTOMATA . . 8.

3 *b*. Cytostome on ventral surface, which alone bears cilia: C. HYPO-STOMATA .... 10.

4. Entire body uniformly covered with cilia .. .. 5.

4 *a*. Anterior end of body bears one or several circlets of longer cilia . 6.

5. Without tentaculiform appendages .. I. Fam. HOLOPHRYINA.

5 *a*. One (at anterior end) or several (among tufts of cilia) tentaculiform appendages ... ... II. Fam. ACTINOBOLINA.

6. Body covered with a special lorica: cytostome surrounded by a circlet of cilia or membranellæ . .. .. III. Fam. COLEPINA.

6 *a*. Body without a lorica . . .. 7.

7. One or two circlets of densely set long cilia at the anterior end. IV. Fam CYCLODININA.

7 *a*. Long cilia densely covering entire anterior end; parasites. V. Fam. PROROTRICHINA.

8. Body flattened laterally; cytostome slit-shaped, occupying anterior part (1/3) of rib-like ventral surface. VI. Fam. AMPHILEPTINA.

8 *a*. Cytostome circular; pharynx surrounded by rod-apparatus ... .. 9.

Cytostome at base of the proboscis or neck; ventral margin of neck bears a row of adoral cilia. ... . VII. Fam. TRACHELINA.

9 *a*. Cytostome at anterior end, ventral; proboscis or neck absent. VIII. Fam. NASSULINA.

10. Body flattened dorso-ventrally; cilia either covering entire ventral surface or disposed on it in several rows; spiniform process absent .. . . XI. Fam. CHLAMYDODONTA.

10 *a*. Cilia in most cases covering only part of the ventral surface; posterior end provided with a spiniform process or platelet . 11.

11. Without adoral row of cilia . ... X. Fam. DYSTERINA.

11 *a*. Adoral row of cilia running from anterior end to cytostome and passing into pharynx XI. Fam. ONYCHODACTYLINA.

12. Cytostome in anterior part of body; if at posterior end, it lies deep in peristome . ... 13.

12 *a*. Cytostome in posterior end of body: endoparasites. XVIII. Fam. ISOTRICHINA.

13. Peristome absent; row of cilia or 1–2 undulating membranes attached to exterior margin of the cytostome. Pharynx—not present in all—bearing cilia or undulating membranes. XII. Fam. CHILIFERA.

13 *a*. Peristome more or less developed . .. . 14.

14. Peristome forms a slight depression in posterior end of body, nearer to its left or right edge; cytostome in anterior end of peristome. Body flattened dorso-ventrally. XIII. Fam. MICROTHORACINA.

14 *a*. Peristome arranged along the long axis of body . . 15.

14 *b*. Peristome situated in middle portion of body, on ventral surface, nearly perpendicular to long axis, densely covered with cilia (characteristic arrangement). Pharynx entirely covered with cilia . . XVII. Fam. PLAGIOPYLINA.

15. Peristome groove-shaped, covered with cilia or naked, not bordered by undulating membrane 16.

15 *a*. Peristome enormous, without cilia, occupying greater part of ventral surface, with a large undulating membrane (sail or sac-shaped) attached to its outer margin. Cilia in majority setiform. XVI. Fam. PLEURONEMINA.

16. Entire body uniformly covered with cilia: peristome occupies anterior 1/3 or 2/3 of ventral surface and is covered with cilia. XIV. Fam. PARAMŒCINA.

16 *a*. Cilia arranged in 3 parallel circles; groove-shaped peristome running from posterior end to middle of body, naked, with row of cilia attached to its right margin, and a tuft of cilia at the posterior end .. . . XV. Fam. UROCENTRINA.

I. Sub-Order GYMNOSTOMATA.

A. Protostomata.

i. Family HOLOPHRYINA Perty.

Key to Genera:

1. Cytostome at the anterior pole, or occupying entire anterior edge of body .. . . 2.

1 *a*. Cytostome at anterior end of body, near anterior pole. 10.

2. Cytostome not surrounded by special (larger) cilia .. 3.

2 *a*. Cytostome at anterior end of body, surrounded by one or several circlets of larger cilia .... 7.

3.	Anterior end of body uniformly rounded or narrowed in the form of a neck, but not flattened	4.
3 *a*.	Anterior end of body flattened laterally and obliquely truncated	6.
4.	Body spherical or ellipsoidal, cytostome at anterior pole, pharynx short	5.
4 *a*.	Body pyriform, narrowed anteriorly; the transversely or obliquely truncated anterior end is occupied entirely by the cytostome; pharynx absent... .	(3) *Enchelys*.
5.	Entire body uniformly covered with cilia; setæ absent	(1) *Holophrya*.
5 *a*.	Cilia scantier or absent at the posterior end. Posterior end bears 1–5 setæ..	(2) *Urotricha*.
6.	Cytostome occupies entire anterior edge of body; pharynx absent	(4) *Spathidium*.
6 *a*.	Cytostome at foremost angle of anterior edge of body; pharynx tubular, surrounded by rods	(5) *Cranotheridium*.
7.	Anterior end of body without special appendages; one adoral circlet of larger cilia.	8.
7 *a*.	Anterior end bears a conical appendage or 4–8 tubercles; two or several adoral circlets of larger cilia	9.
8.	Body pyriform; cytostome round, pharynx tubular or funnel-shaped	(6) *Lagynus*
8 *a*.	Body much flattened, band-like; cytostome slit-shaped; pharynx much flattened	(7) *Trachelophyllum*
9.	Body elongated cylindrical with conical appendage at anterior end; several circlets of cilia . . .	(8) *Lacrymaria*.
9 *a*.	Body cylindrical, vermiform, with 4–8 papillæ at anterior end and 2 circlets of cilia	(9) *Trachelocerca*.
10.	Body ellipsoidal or cylindrical, cytostome near anterior pole, lateral: pharynx conical	11.
10 *a*.	Body elongated cylindrical, pointed anteriorly; cytostome slit-like, disposed laterally at the anterior end; pharynx absent	(12) *Chænia*.
11.	Ciliary rows meridionally arranged; longitudinal groove absent	(10) *Prorodon*
11 *a*.	Ciliary rows spirally arranged; body provided with a spiral groove	(11) *Perispira*.

(1) Genus HOLOPHRYA Ehrenberg.

Key to Species:

1.	Single contractile vacuole at posterior end of body	2.
1 *a*.	Several contractile vacuoles present	*H. multifiliis*.
2.	Ciliary furrows arranged meridionally	3.
2 *a*.	Ciliary furrows arranged spirally	*H. ovum*.
3.	Pharynx absent; body ellipsoidal	*H. simplex*.
3 *a*.	Pharynx tubular	4.
4.	Pharynx without rods	5.
4 *a*.	Pharynx surrounded by rods; body coniform	*H. discolor*.
5.	Body ellipsoidal, trichocysts present, nucleus oval ...	*H. nigricans*.
5 *a*.	Body elongated, cylindrical, trichocysts absent; nuclei numerous	*H. oblonga*.

(2) Genus UROTRICHA Clap. & Lachm.

Key to Species:

1.	Body pyriform, pharynx coniform, surrounded by rods	2.
1 *a*.	Body spherical or ellipsoidal, pharynx funnel-shaped, without rods	3.

2. Posterior end of body truncated, without cilia, bearing a single obliquely attached seta ...	*U. farcta.*
2 *a*. Posterior end of body rounded; entire body covered with cilia; 3–4 setæ present ...	*U. lagenula.*
3. Body spherical, pharynx short; 1 seta ...	*U. furcata.*
3 *a*. Body ellipsoidal, pharynx long; 2 setæ ...	*U. globosa.*

(3) Genus Enchelys Hill.

Key to Species:

1. Single contractile vacuole ...	2.
1 *a*. Numerous contractile vacuoles; anterior end of body obliquely truncated; nucleus ellipsoidal ...	*E. arcuata.*
2. Anterior end of body transversely truncated; nucleus spherical or reniform ...	*E. pupa.*
2 *a*. Anterior end of body obliquely truncated; nucleus ellipsoidal ...	*E. farcimen.*

(4) Genus Spathidium Duj.

Key to Species:

1. Body cylindrical, elongated; nucleus band-like ...	*S. spathula.*
1 *a*. Body sacciform; nucleus spherical ...	*S. liebérkühni.*

(5) Genus Cranotheridium Schew.

Single species ...	*C. tæniatum.*

(6) Genus Lagynus Quenn.

Key to Species:

1. Pharynx conical, surrounded by rods ...	*L. elegans.*
1 *a*. Pharynx cylindrical, dilated anteriorly in the form of a club, without rods ...	*L. crassicollis.*

(7) Genus Trachelophyllum Clap. & Lachm.

Single species ...	*T. apiculatum.*

(8) Genus Lacrymaria Ehrenberg.

Key to Species:

1. Single contractile vacuole ...	2.
1 *a*. Two contractile vacuoles, neck very long ...	*L. olor.*
2. Body without neck, its conical "head" is slightly constricted and bears larger cilia at the posterior portion ...	*L. coronata.*
2 *a*. Body drawn out into a neck, the conical "head" is entirely covered with larger cilia ...	*L. lagenula.*

(9) Genus Trachelocerca Ehrenberg.

Single species ...	*T. phœnicopterus.*

(10) Genus Prorodon Ehrenberg.

Key to Species:

1. Single contractile vacuole at posterior end of body ...	2.
1 *a*. Several contractile vacuoles; pharynx surrounded by rods ...	*P. margaritifer.*

2.	Pharynx surrounded by rods	3.
2 *a*.	Pharynx without rods, nucleus ellipsoidal	*P. edentatus*.
3.	Nucleus elongated cylindrical, band-like; pharynx surrounded by separate rods	4.
3 *a*.	Nucleus ellipsoidal; a special pharyngeal apparatus present	5.
4.	Body ellipsoidal, considerably flattened laterally; pharynx broad, flattened	*P. niveus*.
4 *a*.	Body cylindrical; pharynx conical, narrow	*P. farctus*.
5.	Body spherical, flattened; trichocysts present	*P. armatus*.
5 *a*.	Body ellipsoidal; trichocysts absent	*P. teres*.

(11) Genus Perispira Stein.

Single species .... *P. ovum*.

(12) Genus Chænia Quenn.

Key to Species:

1.	Single contractile vacuole at posterior end of body	2.
1 *a*.	Several contractile vacuoles disposed in a row	*C. crassa*.
2.	Anterior end of body uniformly pointed and provided with a tuft of larger cilia; longitudinal ciliary rows fairly densely arranged	*C. teres*.
2 *a*.	Anterior end drawn out into a neck, bearing longer cilia arranged in spirals; trichocysts present; longitudinal ciliary rows widely separated from each other.	*C. elongata*.

ii. Family Actinobolina Kent.

Key to Genera:

1.	Body ellipsoidal; cilia arranged in tufts in longitudinal furrows; in the middle of each tuft of cilia there is a tentaculiform appendage	(1) *Actinobolus*.
1 *a*.	Body bottle-shaped; cilia arranged singly in longitudinal furrows; anterior end of the body bears one tentaculiform appendage	(2) *Ileonema*.

(1) Genus Actinobolus Stein.

Single species .... *A. radians*.

(2) Genus Ileonema Stokes.

Single species .... *I. dispar*.

iii. Family Colepina Ehrenberg.

Key to Genera:

1.	Anterior end of body bears a circlet of small, elastic (setiform) cilia: body symmetrical about the long axis or bilaterally symmetrical	2.
1 *a*.	Anterior end of body bears 4 triangular membranellæ united at the bases by a circular membrane; body [asymmetrical]	(4) *Stephanopogon*.
2.	Body not covered by a lorica	(1) *Plagiopogon*.
2 *a*.	Body covered by a special lorica	3.
3.	Lorica composed of elongated platelets; body barrel-shaped	(2) *Coleps*.
3'*a*.	Lorica composed of longitudinal rods; body spindle-shaped	(3) *Tiarina*.

(1) Genus Plagiopogon Stein.

Single species .. .. *P. coleps.*

(2) Genus Coleps Nitzsch.

Key to Species:

1. Anterior end of body provided with 15 buccal plates, without spines .... *C. hirtus.*
1 *a*. Anterior end bears 1 or 2 pairs of spines .... 2.
2. One pair of hooked spines; posterior end of body bears 4 spines ... . *C. uncinatus.*
2 *a*. Two pairs of spines; posterior end bears 3 larger spines .... *C amphacanthus.*

(3) Genus Tiarina Bergh.

Single species .. .. *T. fusus.*

(4) Genus Stephanopogon Entz.

Single species.. . ... *S. colpoda.*

iv. Family Cyclodinina Stein.

Key to Genera:

1. Body scantily clothed with cilia arranged in meridional rows; one circlet of membranellæ .. .. (1) *Dinophrya.*
1 *a*. Body naked, with 1 or 2 circlets of membranellæ... .. 2.
2. Body cylindrical, anteriorly drawn out into a contractile proboscis; anterior end bears one circlet of membranellæ; when two circlets are present the second is in the posterior half of the body; membranellæ elastic . . .. (2) *Didinium.*
2 *a*. Body with an equatorial circular constriction, which bears one circlet of elastic membranellæ . .. ... (3) *Mesodinium.*

(1) Genus Dinophrya Bütschli.

Single species... ... . *D. lieberkuhni.*

(2) Genus Didinium Stein.

Key to Species:

1. Body with a single (anterior) circlet of cilia ... . *D. balbianii.*
1 *a*. Body with 2 circlets of cilia .. .. *D. nasutum.*

(3) Genus Mesodinium Stein.

Key to Species:

1. Single circlet of membranellæ, tentacles absent, pharynx surrounded by rods, nucleus spherical .... *M. acarus.*
1 *a*. Several circlets of membranellæ, cytostome surrounded by 4 tentacles, pharynx without rods, nucleus reniform or horseshoe-shaped .... *M. pulex.*

v. Family PROROTRICHINA Bütschli.

Genus BÜTSCHLIA Schuberg.

Key to Species:

1.	Body elongated cylindrical, with neck-like constriction at anterior end; pharynx long (1/3 of body)	*B. parva.*
1 *a*.	Body ovoid or ellipsoidal, without neck-like constriction at anterior end; pharynx short	2.
2.	Body ovoid, uniformly rounded at posterior end; near the vacuole with concretions a tuft of long cilia is given off	*B. neglecta.*
2 *a*.	Body narrowed in the form of a cone at the posterior end and provided with 4 depressions arranged crosswise ..	*B. lanceolata.*

B. Pleurostomata.

vi. Family AMPHILEPTINA Bütschli.

Key to Genera:

1.	Body slightly flattened, or only at the anterior end (as far as the cytostomial slit extends); entire body uniformly covered with cilia arranged in meridional furrows	(1) *Amphileptus.*
1 *a*.	Body flattened considerably laterally, band-shaped or lamelliform; cilia only on one side; if on both, they differ in length and appearance ...	2.
2.	Slit-like cytostome at anterior end of convex ventral surface; pharynx absent ...	3.
2 *a*.	Slit-like cytostome at bottom of peristome at the anterior end of the concave ventral surface; small tubular pharynx present ...	(4) *Loxodes.*
3.	Body elongated, band-shaped, swollen in the middle, with a drawn-out neck, or bent in the form of S; a more or less distinct "mane" of cilia along left margin of the cytostomial slit........	(2) *Lionotus.*
3 *a*.	Body flat, lamelliform; "mane" absent	(3) *Loxophyllum.*

(1) Genus AMPHILEPTUS Ehrenberg.

Key to Species:

1.	Anterior end of body obliquely truncated towards the ventral surface; several contractile vacuoles	2.
1 *a*.	Anterior end of body bent towards the left; single contractile vacuole at posterior end of body..	*A. incurvatus.*
2.	Macronucleus composed of 2 joints; posterior end of body uniformly rounded	*A. claparedii.*
2 *a*.	Macronucleus composed of 4 joints; posterior end of body with a depression; anterior end contains 8–12 trichocysts	*A. carchesii.*

(2) Genus LIONOTUS Wrzesn.

Key to Species:

1.	Single contractile vacuole in posterior end of body ...	2.
1 *a*.	Two contractile vacuoles along the ventral ridge	*L. obtusus.*
1 *b*.	Several contractile vacuoles along the ventral ridge ...	5.

2.	Single nucleus	3.
2 *a*.	Several nuclei; trichocysts absent	*L. pictus.*
3.	Nucleus composed of 2 joints linked together; one row of trichocysts..	4.
3 *a*.	Single elongated nucleus with micronucleus lying in a depression; trichocysts absent	*L. lamella.*
4.	Neck flat and very long	*L. folium.*
4 *a*.	Neck of medium length, bent dorsally	*L. fasciola.*
5.	5–6 contractile vacuoles disposed along the ventral ridge	6.
5 *a*.	In addition to 4–5 small contractile vacuoles along the ventral ridge, there is one large contractile vacuole in the posterior end of the body; nucleus composed of 2 spherical joints	*L. grandis.*
6.	5 contractile vacuoles; trichocysts in anterior end of body; nucleus composed of 2 spherical joints; "mane" [row of long cilia] indistinct	*L. varsoviensis.*
6 *a*.	6 contractile vacuoles; rod-shaped trichocysts distributed throughout the whole body; nucleus composed of 2 oval joints; "mane" distinct	*L. diaphanes.*

(3) Genus Loxophyllum Duj.

Key to Species:

1.	Body elongated ovoid, rounded posteriorly and pointed anteriorly	2.
1 *a*.	Body crescent-shaped, with convex ventral and concave dorsal margins; nucleus band-like; several contractile vacuoles along dorsal margin	*L. armatum.*
2.	Dorsal margin bears several tubercles which sometimes contain bundles of trichocysts; a row of trichocysts runs along the ventral margin; nucleus band-like or beaded; single contractile vacuole in the posterior end	*L. meleagris.*
2 *a*.	Dorsal margin bears no tubercles	3.
3.	Outer margin of body covered with setæ; nucleus composed of 4 joints; several (up to 10) contractile vacuoles along the dorsal margin	*L. setigerum.*
3 *a*.	Nucleus composed of 2 joints; 1–2 contractile vacuoles at posterior end of body	*L. rostratum.*

(4) Genus Loxodes Ehrenberg.

Single species .... *L. rostrum.*

vii. Family Trachelina Ehrenberg.

Key to Genera:

1.	Body pyriform; proboscis short; contractile vacuoles scattered through the whole body; nucleus single or composed of 2 joints; trichocysts absent	(1) *Trachelius.*
1 *a*.	Body cylindrical, pointed posteriorly; proboscis long; contractile vacuoles arranged in a row along dorsal surface; nucleus composed of several joints; trichocysts along ventral edge of proboscis............	(2) *Dileptus.*

(1) Genus Trachelius Schrank.

Single species .... *T. ovum.*

(2) Genus DILEPTUS Duj.

Single species .... *D. anser.*

viii. Family NASSULINA Bütschli.

Genus NASSULA Ehrenberg.

Key to Species:

1.	Pharynx surrounded by rods	2.
1 *a.*	Pharynx funnel-shaped, short, with a swelling at anterior end, without rods; adoral row of cilia absent; single contractile vacuole; trichocysts absent; nucleus spherical	*N. ambiqua.*
2.	Cytostome situated at the bottom of a shallow [vestibulum] dilated in the form of a sac (sometimes indistinct)	3.
2 *a.*	Cytostome situated at the bottom of a pyriform deep vestibulum and leading to a funnel-shaped pharynx, which is dilated anteriorly	9.
3.	Pharynx conical or cylindrical, without a swelling at anterior end	4.
3 *a.*	Pharynx funnel-shaped, with a swelling at anterior end	6.
4.	Pharynx conical; single contractile vacuole situated laterally in middle part of body	5.
4 *a.*	Pharynx cylindrical, short; adoral row of cilia absent; single contractile vacuole in posterior part of body; nucleus ellipsoidal	*N. oblonga.*
5.	Pharynx long, with plasmatic rings; adoral row of cilia present; nucleus spherical; trichocysts sometimes present	*N. aurea.*
5 *a.*	Pharynx short; adoral row of cilia absent; nucleus elongated cylindrical; trichocysts absent	*N. brunnea.*
6.	Body ovoid or cylindrical; adoral row of cilia present.	7.
6 *a.*	Body oval, obliquely truncated at anterior end; 2 contractile vacuoles on left side; nucleus discoidal; trichocysts distributed throughout the whole body .	*N. lateritia.*
7.	Pharynx long; rods numerous; trichocysts absent, or small and dispersed throughout the whole body .	8.
7 *a.*	Pharynx short; rods scanty; single contractile vacuole in lateral part of anterior portion of body; large trichocysts distributed throughout the entire body	*N. rubens.*
8.	1, 2 or 4 (in a row along the dorsal surface) contractile vacuoles; nucleus ellipsoidal; trichocysts present ..	*N. elegans.*
8 *a.*	4 contractile vacuoles arranged alternately on the dorsal and ventral surfaces; nucleus spherical; trichocysts absent	*N. hesperidea.*
9.	Adoral row of cilia and pigment-spot present; 2 contractile vacuoles; nucleus spherical	*N. microstoma.*
9 *a.*	Adoral row of cilia and pigment-spot absent; single contractile vacuole; nucleus large, ellipsoidal	*N. theresæ.*

C. Hypostomata.

ix. Family CHLAMYDODONTA Stein.

Key to Genera:

1.	Entire body covered with cilia; cilia longer on ventral surface than on dorsal	(1) *Orthodon.*
1 *a.*	Only ventral surface or part of it covered with cilia .	2.

2.	Cytostome in anterior part (third or quarter) of body .	3.
2 *a*.	Cytostome in posterior quarter of body; body ovoid; single contractile vacuole in middle of body	(6) *Opisthodon*.
3.	Body dorso-ventrally flattened; adoral row of cilia reaches anterior end of body, or is absent; ventral surface bears numerous longitudinal ciliary rows ...	4.
3 *a*.	Dorsal surface very convex; adoral row of cilia encircling almost entire body; ventral surface with only 7 longitudinal ciliary rows	(5) *Phascolodon*.
4.	Entire ventral surface covered with longitudinal ciliary rows	5.
4 *a*.	Only middle area of ventral surface covered with longitudinal ciliary rows; posterior part of body drawn out into a caudiform appendage..............	(4) *Scaphidiodon*.
5.	Anterior end of body pointed [and bent] in the form of a rostrum, or narrowed and rounded; ciliary rows curved around cytostome in the form of arches; band-like stripe absent..................................	(2) *Chilodon*.
5 *a*.	Anterior end of body dilated; ciliary rows curved around cytostome and running parallel to anterior edge of the body; along the outer margin of the body, within the endoplasm, there is a special transversely striated band-like stripe.........................	(3) *Chlamydodon*.

(1) Genus Orthodon Gruber.

Key to Species:

1.	Anterior end drawn out into a large rostrate process; contractile vacuole in the narrowed posterior end of the body; nucleus ellipsoidal.	*O. hamatus*.
1 *a*.	Anterior end bent to the left in the form of a rostrum; contractile vacuole in middle part of body, on the left side; nucleus reniform	*O. parvirostrum*.

(2) Genus Chilodon Ehrenberg.

Key to Species:

1.	Body pointed in the form of a rostrum at the anterior end and bent to the left side; rod-apparatus conical; adoral row of cilia present	2.
1 *a*.	Body rounded at both ends; adoral row of cilia absent	4.
2.	Rostrum slightly bent to the left side; rod-apparatus long	3.
2 *a*.	Rostrum strongly bent to the left side; rod-apparatus short; posterior end of body pointed and provided with a spiniform process on the dorsal surface ..	*C. caudatus*.
3.	Body flattened dorso-ventrally; 2–3 or more contractile vacuoles..	*C. cucullulus*.
3 *a*.	Body flattened at the anterior end; posterior end cylindrical; single contractile vacuole in posterior end of body..	*C. propellens*.
4.	Rod-apparatus long and bent archwise or spirally ..	5.
4 *a*.	Rod-apparatus short, conical, straight; dorsal surface with a spiniform process; 3 contractile vacuoles.	*C. gouraudi*.
5.	Rod-apparatus cylindrical, bent archwise; nucleus ellipsoidal; single contractile vacuole in middle portion of body	*C. dubius*.
5 *a*.	Rod-apparatus conical, spirally twisted; nucleus spherical; single contractile vacuole in posterior end of body	*C. dentatus*.

(3) Genus Chlamydodon Ehrenberg.

Single species .... *C. mnemosyne.*

(4) Genus Scaphidiodon Stein.

Single species .... *S. navicula.*

(5) Genus Phascolodon Stein.

Single species .... *P. vorticella.*

(6) Genus Opisthodon Stein.

Single species .... *O. niemeccensis.*

x. Family Dysterina Clap. & Lachm.

Key to Genera:

1.	Entire ventral surface covered with cilia; cytostome slit-like, pharynx short, surrounded by rods	(1) *Ægyria.*
1 *a.*	Only part of ventral surface covered with cilia; cytostome round, pharynx long, conical [unarmed] .	2.
2.	Cilia arranged along arched longitudinal area in middle of ventral surface; body flattened	(2) *Trochilia.*
2 *a.*	Cilia arranged along right edge of ventral surface; body flattened and bent in the form of a bivalve shell	(3) *Dysteria.*

(1) Genus Ægyria Clap. & Lachm.

Single species .... *Æ. oliva.*

(2) Genus Trochilia Duj.

Key to Species:

1.	Anterior end pointed and bent to the left side; dorsal surface provided with 5–6 convex ridges	*T. sigmoides.*
1 *a.*	Anterior end obliquely truncated to the left side and slightly concave; dorsal surface smooth; anterior end bears one large cilium	*T. palustris.*

(3) Genus Dysteria Huxley.

Key to Species:

1.	Body ovoid	2.
1 *a.*	Body elongated cylindrical	3.
2.	Left "valve" scalloped at anterior end and provided with one longitudinal furrow; [its posterior end bears] a conical spiniform process; 2 contractile vacuoles along the free margin of the left side	*D. monostyla.*
2 *a.*	Left "valve" with 2–3 scallops at anterior end and 2–3 oblique ridges; [its posterior end bears] a hatchet-shaped process; 4 contractile vacuoles	*D. armata.*
3.	Anterior end obliquely truncated; dorsal surface very convex; single contractile vacuole; a conical spiniform process [at the posterior end]	*D. fluviatilis.*
3 *a.*	Anterior end dilated and rounded; posterior end more or less narrowed and rounded	4.
4.	Pharyngeal apparatus bent at an angle; 2 contractile vacuoles; a conical spiniform process present.........	*D. sulcata.*
4 *a.*	Pharyngeal apparatus conical, very long; 2 contractile vacuoles along free margin of left "valve"; a lanceolate flat process present......	*D. lanceolata.*

xi. Family Onychodactylina Entz.

Genus Onychodactylus Entz.

Single species.. .... *O. acrobates.*

II. Sub-Order TRICHOSTOMATA.

xii. Family Chilifera Bütschli.

Key to Genera:

1.	Pharynx absent: A. Sub-Family Apharyngeata .	2.
1 *a*.	Pharynx present: B. Sub-Family Pharyngeata ...	8.
2.	Cytostome on ventral surface; peristome absent	3.
2 *a*.	Cytostome at end of a longitudinal groove (peristome) commencing at anterior end of body; 1–2 undulating membranes; posterior end of body bears a tactile seta	(7) *Cryptochilum.*
3.	Outer cytostomial margin bears cilia	(1) *Blepharostoma.*
3 *a*.	Cytostomial margins bear cilia and undulating membranes or only an undulating membrane	4.
4.	Two undulating membranes; one on the right, the other on the left cytostomial margin	5.
4 *a*.	Single undulating membrane	6.
5.	Cytostome arranged along the long axis of body	(2) *Dichilum.*
5 *a*.	Cytostome arranged obliquely to the long axis of body.	(3) *Dallasia.*
6.	Single undulating membrane along left cytostomial margin; the right one bears a row of cilia	7.
6 *a*.	Single arcuate undulating membrane bordering left, anterior and right cytostomial margins	(6) *Stegochilum.*
7.	Cytostome arcuate, at anterior pole of body	(4) *Plagiocampa.*
7 *a*.	Cytostome oval, on ventral surface	(5) *Uronema.*
8.	Cytostome at the obliquely truncated anterior end of body.......	(8) *Leucophrys.*
8 *a*.	Cytostome on ventral surface	9.
9.	Outer margin of cytostome naked or bearing [one or two] undulating membranes	10.
9 *a*.	Outer, left edge [of cytostome] reniform, cytostome [surrounded] by cilia; pharynx bears an undulating membrane; near the cytostome is a special lens-shaped body	(19) *Ophryoglena.*
10.	Outer cytostomial margin naked	11.
10 *a*.	Outer cytostomial margin bears one or two (outer) undulating membranes	12.
11.	Single undulating membrane attached to dorsal wall of pharynx; cytostome oval	(9) *Monochilum.*
11 *a*.	Dorsal wall of pharynx bears a row of cilia; cytostome small; adoral row of cilia leading to cytostome, posterior end bears a tactile seta	(10) *Loxocephalus.*
12.	Outer undulating membrane in the form of a platelet, awning, or sac; pharynx bears an undulating membrane	13.
12 *a*.	Large cytostome (resembling a peristome) covered by a large undulating membrane attached to its outer margins; pharynx naked..............	17.
13.	Body regularly ellipsoidal or reniform, sometimes slightly flattened	14.
13 *a*.	Body irregular: anterior end turned to one side	16.

14.	Entire body covered with cilia	15.
14 *a*.	Only middle zone of body ciliated; outer undulating membrane attached to left, anterior and right cytostomial margins; pharynx bears a row of cilia; tactile seta at posterior end............................ ..	(13) *Urozona.*
15.	Outer undulating membrane attached to left, posterior and right cytostomial margins; inner undulating membrane resembles a row of cilia	(11) *Chasmatostoma.*
15 *a*.	Outer undulating membrane attached to left, anterior and, sometimes, posterior cytostomial margins; inner undulating membrane in the form of a platelet	(12) *Glaucoma.*
16.	Anterior end of body turned to the left; outer undulating membrane attached to left, anterior and right cytostomial margins; inner undulating membrane valve-shaped	(14) *Colpidium.*
16 *a*.	Anterior end of body turned to the right; outer undulating membrane attached to posterior cytostomial margin	(15) *Colpoda.*
17.	Large outer undulating membrane attached to left (and posterior in *Frontonia*) cytostomial margin; pharynx short, sac-shaped	18.
17 *a*.	Outer undulating membrane attached to right cytostomial margin; pharynx long, tubular; posterior end of body bears a tactile seta	(18) *Philaster.*
18.	Cytostome small, right cytostomial margin bears several rows of cilia; long peristomial groove present.	(16) *Frontonia.*
18 *a*.	Cytostome large (1/3 body-length); right cytostomial margin bears narrow undulating membrane...	(17) *Disematostoma.*

A. Sub-Fam. *APHARYNGEATA.*

(1) Genus BLEPHAROSTOMA Schew.

Single species............ .... *B. glaucoma.*

(2) Genus DICHILUM Schew.

Key to Species:

1.	Body elongated oval; trichocysts absent: contractile vacuole at posterior end of body	*D. cuneiforme.*
1 *a*.	Body oval; trichocysts present; contractile vacuole in middle of body	*D. wrzesniowskii.*

(3) Genus DALLASIA Stokes.

Single species .... *D. frontata.*

(4) Genus PLAGIOCAMPA Schew.

Single species . ... *P. mutabile.*

(5) Genus URONEMA Duj.

Key to Species:

1.	Body narrower anteriorly; cilia denser at anterior than at posterior end; a tactile seta is attached to the posterior end, in which the contractile vacuole lies	*U. marina.*
1 *a*.	Body ellipsoidal; entire body uniformly ciliate; tactile seta absent; contractile vacuole in posterior half of body	*U. ovale.*

(6) Genus STEGOCHILUM Schew.

Single species .... *S. fusiforme.*

(7) Genus CRYPTOCHILUM Maupas.

Key to Species:

1.	Body elongated oval or pyriform; anterior end transversely truncated; cytostome in middle of body, on ventral surface	2
1 *a.*	Body reniform or ellipsoidal, and twisted; cytostome in anterior half of body	3.
2.	Body elongated oval; tactile seta at an angle to the long axis of body; nucleus spherical.	*C. nigricans.*
2 *a.*	Body pyriform; tactile seta in long axis of body nucleus ellipsoidal...	*C. elegans.*
3.	Body reniform; anterior end bent to ventral surface; tactile seta in long axis of body	*C. griseolum.*
3 *a.*	Body ellipsoidal; its anterior half is turned to the left. Peristome bent spirally; tactile seta at an angle to long axis of body	*C. tortum.*

B. Sub-Fam. *PHARYNGEATA.*

(8) Genus LEUCOPHRYS Ehrenberg.

Single species .... *L. patula.*

(9) Genus MONOCHILUM Schew.

Single species . ... *M. frontatum.*

(10) Genus LOXOCEPHALUS Eberh.

Single species .... *L. granulosus.*

(11) Genus CHASMATOSTOMA Engelm.

Single species .. .. *C. reniforme.*

(12) Genus GLAUCOMA Ehrenberg.

Key to Species:

1.	Tactile seta absent	2.
1 *a.*	Posterior end of body bears a tactile seta; body ovoid; outer undulating membrane attached to left, anterior and right cytostomial margins; inner undulating membrane in the form of a triangular tongue	*G. setosa.*
2.	Body ovoid	3.
2 *a.*	Body elongated oval; anterior end turned slightly to the left and bent to the ventral surface; outer undulating membrane attached to left cytostomial margin; inner undulating membrane in the form of a triangular platelet	*G. colpidium.*
3.	Body dorso-ventrally flattened; dorsal and ventral surfaces similar	4.
3 *a.*	Ventral surface very concave; body reniform, when viewed laterally; outer undulating membrane attached to left and anterior cytostomial margins; inner undulating membrane in the form of a triangular platelet	*G. reniformis.*

4.	Cytostome in anterior part of body; outer undulating membrane attached to left, anterior and right cytostomial margins..........	5.
4 *a*.	Cytostome large, in middle of body; outer undulating membrane attached to left cytostomial margin; inner undulating membrane broader than outer	*G. macrostoma.*
5.	Both poles similar; cytostome in anterior third; outer undulating membrane attached to entire left margin of cytostome; inner undulating membrane in the form of a quadrangular platelet	*G. scintillans.*
5 *a*.	Anterior end narrowed; cytostome in anterior quarter; outer undulating membrane attached to anterior part of left cytostomial margin; inner undulating membrane in the form of a triangular tongue	*G. pyriformis.*

(13) Genus Urozona Schew.

Single species ... . *U. bütschlii.*

(14) Genus Colpidium Stein.

Single species .... *C. colpoda.*

(15) Genus Colpoda O. F. Müller.

Key to Species:

1.	Body reniform, rounded at the ends; cytostome in a depression in middle of ventral surface; pharynx short; nucleus ellipsoidal	*C. cucullus.*
1 *a*.	Body reniform, pointed at the ends: cytostome in a depression in anterior third of body; pharynx very short; nucleus spherical.	*C. steinii.*

(16) Genus Frontonia Ehrenberg.

Key to Species:

1.	Body dilated at anterior and narrowed at posterior end; single contractile vacuole in middle of body ..	2.
1 *a*.	Body cylindrical, rounded at both ends; 2 contractile vacuoles, one in anterior, the other in posterior part of body; peristome groove very long..	*F. fusca.*
2.	Body slightly flattened dorso-ventrally; peristome groove long; micronuclei numerous; colourless or green	*F. leucas.*
2 *a*.	Body considerably flattened dorso-ventrally; posteriorly pointed; peristome groove short; colour violet or blue; pigment-spot in anterior end	*F. acuminata.*

(17) Genus Disematostoma Lauterb.

Single species .... *D. bütschlii.*

(18) Genus Philaster Fabre-Dom.

Single species .... *P. digitiformis.*

(19) Genus Ophryoglena Ehrenberg.

Key to Species:

1.	Body elongated oval, dilated and rounded at anterior end, narrowed towards posterior end.	2.
1 *a*.	Body oval, both ends pointed in the form of a lemon; single contractile vacuole in posterior part of body, on right side; macronucleus large, reniform	*O. citreum.*

2.	Two contractile vacuoles; nucleus elongated cylindrical; trichocysts and pigment-spot absent ..	*O. flava.*
2 *a*.	Single contractile vacuole in middle part of body; nucleus ellipsoidal; trichocysts and pigment-spot present ...	3.
3.	Body pyriform, posterior end pointed; colour yellow; pigment-spot red; contractile vacuole on left side .	*O. flavicans.*
3 *a*.	Body elongated oval, rounded posteriorly; colour dark-brown; pigment-spot black; contractile vacuole on right side ...	*O. atra.*

xiii. Family Microthoracina Wrzesn.

Key to Genera:

1.	Free-living forms; cilia rather scanty . .	2.
1 *a*.	Parasitic forms; cilia covering the body densely ..	4.
2.	Cytostome at bottom of peristome, on one side of the body ...	3
2 *a*.	Cytostome at posterior end, at the base of a conical process, which is provided with a tuft of tactile setæ ...	(5) *Trichorhynchus.*
3.	Peristome and cytostome near right edge of body; 2 undulating membranes; posterior end bears tactile setæ ...	(1) *Cinetochilum.*
3 *a*.	Peristome and cytostome near left edge of body; single undulating membrane; tactile setæ absent	(2) *Microthorax*
4.	Body triangular; peristome and cytostome on left side; undulating membrane attached to right peristomial margin ...	(3) *Ptychostomum.*
4 *a*.	Body elongated oval; peristome and cytostome on right side; undulating membrane sacciform; a row of cilia extending from anterior end of body to cytostome; anterior end bears a tuft of cilia	(4) *Ancystrum.*

(1) Genus Cinetochilum Perty.

Single species ... *C. margaritaceum.*

(2) Genus Microthorax Engelm.

Key to Species:

1.	Entire body ciliated; cytostome nearer to left margin; nucleus ellipsoidal ...	*M. sulcatus.*
1 *a*.	Only ventral surface ciliated; cytostome nearer to the middle; nucleus spherical ...	*M. pusillus.*

(3) Genus Ptychostomum Stein.

Single species... *P. sænuridis.*

(4) Genus Ancystrum Maupas.

Key to Species:

1.	Body broader at anterior end and flattened dorsoventrally; cytostome at posterior end; pharynx tubular; nucleus reniform ...	*A. mytili.*
1 *a*.	Body narrowed at both poles and flattened laterally; cytostome in posterior third of body; posterior end bears a tuft of tactile setæ; pharynx absent; nucleus ellipsoidal ...	*A. veneris.*

(5) Genus Trichorhynchus Balb.

Single species.............. .... *T. tuamotuensis.*

xiv. Family Paramæcina Duj.

Genus Paramæcium Hill.

Key to Species:

1.	Body elongated oval; narrowed and rounded at both ends; peristome occupies 2/3 of body-length	2.
1 *a*.	Body oval or ovoid, obliquely truncated at anterior end and dilated at posterior end; peristome occupies anterior third of body	3.
2.	Both ends similarly narrowed and rounded; 2 spherical micronuclei	*P. aurelia.*
2 *a*.	Anterior end cylindrical, posterior end conical, bearing a tuft of cilia; single ellipsoidal micronucleus	*P. caudatum.*
3.	Trichocysts present; 2 contractile vacuoles; cytopyge at the posterior pole; zoochlorellæ present	*P. bursaria.*
3 *a*.	Trichocysts and zoochlorellæ absent; single contractile vacuole; cytopyge on ventral surface at posterior end of body	*P. putrinum.*

xv. Family Urocentrina Clap. & Lachm.

Genus Urocentrum Nitzsch.

Single species... . . .. *U. turbo.*

xvi. Family Pleuronemina Bütschli.

Key to Genera:

1.	Peristome large, occupying greater part of ventral surface	2.
1 *a*.	Peristome in the form of a small depression at anterior end of body. Undulating membrane sacciform, encircling the whole peristome, except its anterior margin.	(5) *Balantiophorus.*
2.	Peristome very large, oval, occupying nearly the whole ventral surface; the right margin bears a large undulating membrane; the left margin bears a small one, and [a third] membrane is situated inside the peristome; contractile vacuole in middle of body ...	(1) *Lembadion.*
2 *a*.	Peristome groove-shaped or dilated posteriorly in the form of a flask; contractile vacuole at posterior end.	3.
3.	Peristome in the form of a groove dilated in the shape of a flask, occupying 2/3 of the body-length; one undulating membrane present	4.
3 *a*.	Peristome in the form of a groove extending to middle of body; 2 undulating membranes: one (large) on the right, the other on the left side	(4) *Lembus.*
4.	Tactile seta absent; contractile vacuole in posterior part of body	(2) *Pleuronema.*
4 *a*.	Posterior end bears 1–7 tactile setæ; contractile vacuole at posterior pole	(3) *Cyclidium.*

(1) Genus Lembadion Perty.

Single species............ .... *L. bullinum.*

(2) Genus Pleuronema Duj.

Single species ... *P. chrysalis.*

(3) Genus Cyclidium Hill.

Key to Species:

1.	Entire body covered with cilia; posterior end bears one tactile seta ...	2.
1 *a*.	Only anterior end of body ciliated; the cilia arranged in 4–5 circlets; posterior end bears 7 tactile setæ ...	*C. heptatrichum.*
2.	Body elongated oval, with rounded ends; left peristomial margin with one indentation; right margin crescentic ...	*C. glaucoma.*
2 *a*.	Body oval; anterior end transversely truncated: left peristomial margin with 2 indentations; right margin straight ...	*C. citrullus.*

(4) Genus Lembus Cohn.

Key to Species:

1.	Body elongated cylindrical, very long ...	2.
1 *a*.	Body elongated oval, very short; left undulating membrane very small ...	*L. pusillus.*
2.	Posterior end of body bears a tactile seta; nucleus composed of two joints ...	*L. verminus.*
2 *a*.	Tactile seta absent; nucleus ellipsoidal ...	*L. elongatus.*

(5) Genus Balantiophorus Schew.

Key to Species:

1.	Body elongated oval; setiform cilia denser at anterior end ...	3.
1 *a*.	Body ellipsoidal, transversely truncated at posterior end; short cilia covering entire body uniformly; undulating membrane attached to right, posterior, and posterior half of left peristomial margins ...	*B. bursaria.*
2.	Cilia densely arranged in longitudinal rows; undulating membrane attached to left, posterior, and right peristomial margins ...	*B. minutus.*
2 *a*.	Cilia scantily arranged; undulating membrane attached to left, posterior, and posterior half of right peristomial margins ...	*B. elongatus.*

xvii. Family Plagiopylina Schew.

Genus Plagiopyla Stein.

Single species... ... *P. nasuta.*

xviii. Family Isotrichina Bütschli.

Key to Genera:

1.	Ciliary rows disposed meridionally; pharynx covered with cilia; several contractile vacuoles in middle part of body; nucleus attached to ectoplasm by special plasmatic stalks ...	(1) *Isotricha.*
1 *a*.	Ciliary rows arranged spirally; pharynx naked; single contractile vacuole at posterior end; nucleus free ..	(2) *Dasytricha.*

(1) Genus Isotricha Stein.

Key to Species:

1.	Body elongated oval, obliquely truncated at posterior end; cytostome on truncated surface; pharynx in the form of a straight cylindrical tube directed forwards; nucleus long, oval	*I. prostoma.*
1 *a.*	Body ovoid, with a depression on ventral surface of posterior third of body; cytostome in the depression; pharynx in the form of a curved tube directed backwards; nucleus short, oval	*I. intestinalis.*

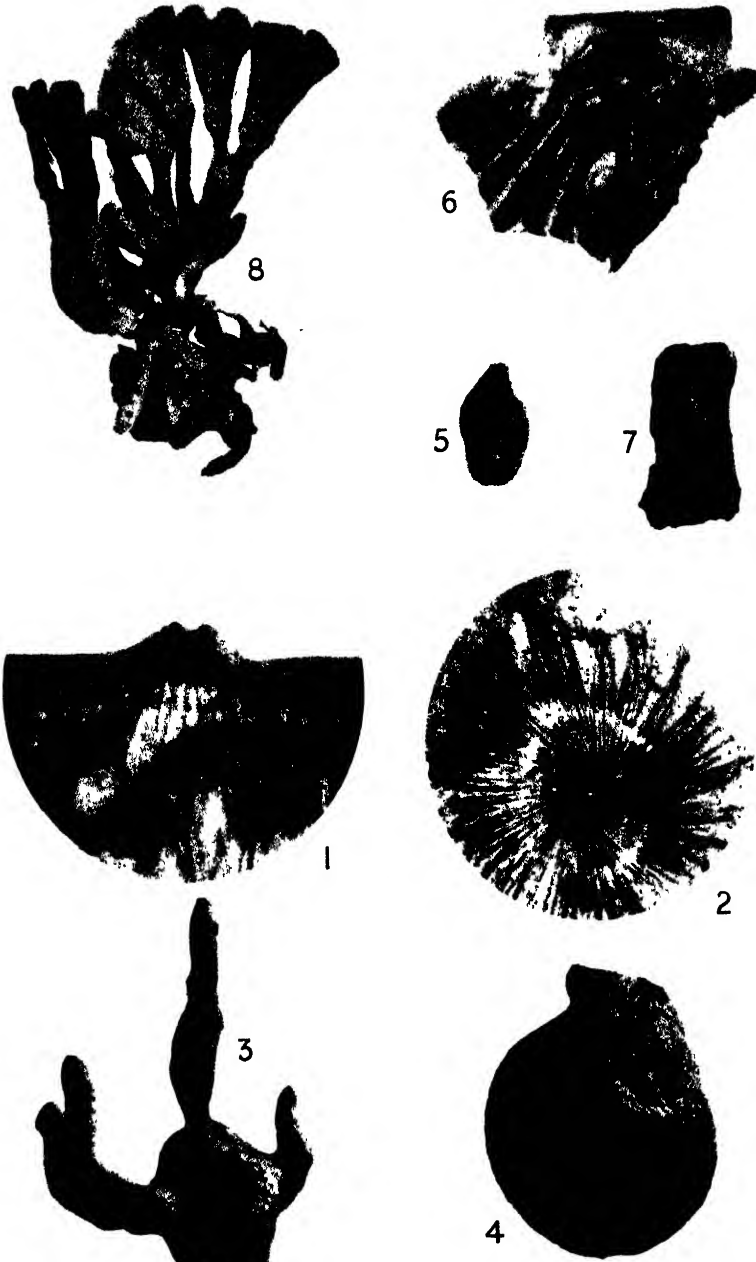
(2) Genus Dasytricha Schuberg.

Single species .... *D. ruminantium.*

III. Sub-Order ASTOMATA.*

xix. Family Opalinina Stein.

* The keys to the genera and species of Astomata are omitted, since this group has been more adequately dealt with in recent times (chiefly by Cépède, C. (1910), "Recherches sur les infusoires astomes," Arch. Zool. Exp. iii. 341, and Metcalf, M. M. (1909), "*Opalina*, etc.", Arch. f. Protistenk. xiii. 195, and (1923), "The opalinid ciliate infusorians," Smithsonian Inst., Nation. Mus. Bull. 120).



SPONGES FROM MARIA ISLAND, TASMANIA

25. On a Collection of Sponges from Maria Island, Tasmania.

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[Received February 7, 1927: Read April 26, 1927.]

(Plate I.†; Text-figures 1–4.)

Introduction.

The collection of sponges which was made by the late Professor A. Dendy in 1914 is poor in new species, only one being present. Although the collection is a small one, it is representative enough to show that the sponge fauna of this part of the Tasmanian coast is typically Australian, 25 out of the 36 species having been recorded from no other region; further, the collection resembles the fauna of Southern Australia as might be expected. The chief interest of the collection, apart from this, resides in the light that various specimens, especially those with sand included in their tissues, throw on general problems connected with sponges. The Calcarea are very poorly represented as also are the Astrotetraxonida, although one of the sponges belonging to this latter group is an interesting specimen of *Jaspis stellifera* with complete suppression of microscleres. The Sigmatotetraxonida, as is usual, form the greater part of the collection, and include a very interesting new species of *Hamigera*. There are especially fine specimens of *Echinoclathria intermedia*, *Rhabdosigma mammillata*, and *Polymastia craticia*. Several of the sponges, especially the specimens of *Rhaphidophlus typicus* var. *stellifer* and *Crella incrustans* var. *digitata*, show considerable variation in external form, illustrating the principle that the external form of a sponge is not necessarily rigidly fixed and characteristic of the species but may vary owing to purely local conditions. An investigation of the Maria Island Sigmatotetraxonida has made it possible to clear up definitely cases of suspected synonymy of species. The Euceratosa do not include any new or interesting forms.

As all the species, except one, have been described previously, it will only be necessary to give a complete list of the species present in the collection, noting any point of special interest, and a more detailed description of the new species of *Hamigera*.

For the opportunity to report on this collection of sponges I am indebted to the late Professor A. Dendy. My work has

* Communicated by R. Kirkpatrick, F.Z.S.

† For explanation of the Plate, see p. 439.

been greatly facilitated by the kindness of the authorities of the British Museum, to whom I must express my sincere gratitude, in allowing me to conclude my investigation at the Museum with the help of the National Collection, etc. Also, I must here tender my very best thanks to Mr. Kirkpatrick and Mr. M. Burton, of the British Museum, for the untiring help and excellent advice that they have offered me throughout.

All specimens were obtained from a station three miles north of Maria Island, Tasmania.

The collection comprises 36 species, of which the following is a complete list:—

Order **CALCAREA.**

Family Grantiidæ.

1. *Leucandra amorpha* (Poléjaeff).

Family Amphoriscidæ.

2. *Leucilla saccharata* (Haeckel).

Order **TETRAXONIDA.**

Suborder **ASTROTETRAXONIDA.**

Family Stellettidæ.

3. *Stelletta communis* (Sollas).
4. *Jaspis stellifera* (Carter).

Suborder **SIGMATOTETRAXONIDA.**

Family Haploscleridæ.

Subfamily Chalininæ.

5. *Chalinopsilla australis* var. *reticulata* Lendenfeld.

Family Desmacidonidæ.

Subfamily Esperellinæ

Section **Mycaleæ.**

6. *Mycale parasitica* (Carter), var. *arenosa* Hentschel.
7. *Mycale raphidiophora* Hentschel.
8. *Mycale obscura* (Carter).

Subfamily Ectyoninæ.

Section **Clathrieæ.**

9. *Rhaphidophlus typicus* (Carter), var. *stellifer* Hallmann.
10. *Clathria rubens* (Lendenfeld).
11. *Clathria transiens* Hallmann.

12. *Wilsonella pyramida* (Lendenfeld).
13. *Wilsonella dura* (Whitelegge).
14. *Echinoclathria arenifera* Carter.
15. *Echinochalina glabra* Ridley & Dendy.
16. *Echinochalina intermedia* (Whitelegge).
17. *Raspailia cacticutis* (Carter).
18. *Rhabdosigma mammillata* (Whitelegge).

Section **Myxilleæ.**

19. *Plumohalichondria purpurea* Carter.
20. *Crella incrustans* Carter, var. *digitata* Hallmann.
21. *Hamigera dendyi*, sp. n.

Section **Phoriospongineæ.**

22. *Phoriospongia kirkii* (Carter).

Section **Tedanieæ.**

23. *Tedania commixta* Ridley & Dendy.
24. *Tedania digitata* (Schmidt).

Subfamily Axinellinæ.

Section **Axinelleæ.**

25. *Phakellia flabellata* Carter.

Family Clavulidæ.

Subfamily Spirastrellinæ.

26. *Sigmosceptrella fibrosa* Dendy.

Subfamily Suberitinæ.

27. *Suberites carnosus* Johnston.
28. *Suberites antarcticus* Carter.
29. *Suberites caminatus* Ridley & Dendy
30. *Suberites difficilis* Dendy, var.
31. *Polymastia craticia* Hallmann.

Order **EUCERATOSA.**

Family Darwinellidæ.

32. *Dendrilla cavernosa* Lendenfeld.

Family Spongelidæ.

33. *Spongelia elastica* Schulze, var. *crassa* Dendy.
34. *Spongelia elegans* Nardo.
35. *Spongelia hirciniformis* (Carter).

Family SPONGIIDÆ.

36. *Leiosella illawarra* Lendenfeld.

For the sake of brevity the synonymy has been omitted for those species in which it has been fully worked out and is well known. The synonymy has been included in certain cases where it is not well known or additions have been made from a study of the present collection.

Order **CALCAREA.**

Family GRANTIIDÆ.

1. LEUCANDRA AMORPHA (Poléjaeff).

This species is represented by a single tubular specimen, contracted at the base but with no definite stalk, measuring 75 mm. in height and 15 mm. in diameter.

Previously known Distribution.—Bermudas (*Sollas*).

Registered No. 111.

Family AMPHORISCIDÆ.

2. LEUCILLA SACCHARATA (Haeckel).

The three specimens of this very common Australian species are all of the typical form, long cylindrical tubes.

Previously known Distribution.—Australia: Bass Strait (*Haeckel*); Port Jackson (*Lendenfeld*); Port Denison (*Lendenfeld*); Port Philip (*Dendy*).

Registered Nos. II, V, VI.

Order **TETRAXONIDA.**

Suborder **ASTROTETRAXONIDA.**

Family STELLETTIDÆ.

3. STELLETTA COMMUNIS (Sollas).

A single small subspherical specimen incrusted with foreign bodies among which are two small calcareous sponges.

Previously known Distribution.—Australia: Moncoeur Island, Bass Strait, Twofold Bay, Port Jackson (*Sollas*).

Registered No. IV.

4. JASPIS STELLIFERA (Carter).

Amorphina stellifera Carter, 1879 B, p. 344.
Stellettinopsis stellifera Ridley, 1885, p. 477
Coppatias stellifera Sollas, 1888 A, p. 208.
Coppatias coriaceus Sollas, 1888 A, p. 207.

Coppatias tuberculatus Sollas, 1888 A, p. 207.
Coppatias purpureus Sollas, 1888 A, p. 207.
Coppatias luteus Sollas, 1888 A, p. 207.
Jaspis stellifera Burton MS.

This common South Australian species is represented by a single specimen which, as far as external form is concerned, closely resembles typical specimens of the species. The arrangement of the skeleton is also typical with the exception that the microxea appear to be the only microscleres present, no trace of the characteristic asters having been found. As both the general arrangement of the skeleton and the form of the oxea point to an undoubted affinity with *Jaspis stellifera*, I would suggest that this is a case where the Astrose microscleres have entirely dropped out of the spiculation—a condition so often met with in other Astrotetraxonida. It is worthy of note in this connection that the number of asters present in different specimens of this species is known to vary considerably.

Previously known Distribution.—South Australia (*Carter*, *Sollas*); Prince of Wales Channel, Torres Strait (*Ridley*).

Registered No. LXII.

NOTE.—For the synonymy given above I am indebted to Mr. M. Burton, M.Sc., of the British Museum, who has had considerable experience of this species, and has kindly allowed me to use his results.

Suborder **SIGMATOTETRAXONIDA.**

Family HAPLOSCLERIDÆ.

Subfamily CHALININÆ.

5. CHALINOPSILLA AUSTRALIS var. RETICULATA Lendenfeld.

A single specimen represented by numerous fragments and agreeing very closely with the description of the type.

Previously known Distribution.—E. Coast of Australia, New Zealand (*Lendenfeld*).

Registered No. LIV.

Family DESMACIDONIDÆ.

Subfamily ESPERELLINÆ.

Section **Mycaleæ.**

6. MYCALE (MYCALE) PARASITICA (Carter), var. ARENOSA Hentschel.

From the arrangement of the dermal skeleton this species must be included in Topsent's (1924 B) subgenus *Mycale*.

Previously known Distribution.—S. Australia, Port Philip Heads (*Carter*, *Dendy*); S.W. Australia (*Hentschel*).

Registered Nos. XL, XLIII.

7. Mycale (Carmia) raphidiophora Hentschel.

From the arrangement of the dermal skeleton this species must be included in Topsent's (1924 B) subgenus *Carmia*.

Previously known Distribution.—S.W. Australia (*Hentschel*).

Registered No. LXXXVII.

8. Mycale (Ægagropila) obscura (Carter).

The two specimens representing this species both incrust Pecten shells. They fall into Topsent's subgenus *Ægagropila*.

Previously known Distribution.—S.W. Australia, Aru Island, East Indies (*Hentschel*): Fremantle (*Carter*).

Registered No. LXXIV A & B.

Subfamily Ectyoninæ.

Section **Clathrieæ**.

9. Rhaphidophilus typicus (Carter), var. stellifer Hallmann, 1912, p. 200.

The nine specimens of this species agree very closely, as regards skeletal characters, with the holotype as described and figured by Hallmann (*l. c.*), but show considerable range of external form. Seven of the specimens agree with the type in being flabellate and stipitate; but, contrary to Hallmann's findings, oscula are present and are numerous, conspicuous, and scattered over both surfaces of the flabellate expansion. All these specimens exhibit the curious stellate grooving round the oscules which gives the holotype its name, but there is a good deal of variation in the form of the "asterisk" (group of stellate grooves). In specimens R. N. XVI & XXIII all the grooves forming the "asterisks" are equally well developed; but in R. N. LVIII A & B one groove of the asterisk is much clearer and better defined than the others, while in R. N. LVIII C only this one groove is developed. It is noticeable that in all the small specimens there is a distinct tendency for one groove to be much clearer and better defined than the others, and it seems probable that this is a character of the young sponge, while the "radiate asterisk" is characteristic of the adult.

The remaining two specimens differ considerably, both from those described above and from each other. R. N. XXXVI may still be described as flabellate and stipitate, but both the stalk and the lamina are much more massive than in any of the preceding forms. The lamina is thick, especially towards the margin, which is notched and shows a tendency to form cylindrical outgrowths in all directions. Thus the dominant growth tendency is in the direction of plate formation, but the development of incipient outgrowths round the margin shows that there is also a tendency towards a branching habit. The "asterisks" are only faintly indicated, and the oscula are few and scattered equally over both surfaces and the margins.

R. N. XLIV branches dichotomously and the branches lie approximately in one plane. There is a tendency to fusion and anastomosis, two of the main branches having fused in several places. The oscula are small and scattered and there are no "asterisks." In external form it approximates to *R. typicus* var. *geminus* and var. *proximus*, but investigation of the spiculation shows it to be a var. *stellifer* with the echinating acanthostyles very much reduced in number. It seems probable that the external form of *R. typicus* var. *stellifer* is subject to a great deal of variation, and that R. N. XXXVI and XLIV are variants, the former retaining to a certain extent the characteristic external form but showing transition to a branching habit, while the latter is an extreme variant unrecognisable as *R. typicus* var. *stellifer* except by microscopic investigation.

In view of the fact that the external form of the present variety is so variable, and that one specimen resembles var. *anchoratus* while another resembles var. *geminus* and var. *proximus*, the range of variation of the spicules in all the specimens was investigated to ascertain whether the variation in a single individual was sufficiently great for all four varieties to be regarded as synonyms. Distinction between the various varieties of this species is based largely on the character of the acanthostyles, but these vary considerably in any one specimen and also from individual to individual, both in size and degree of spining; the spines may be much larger and more strongly developed than in a typical acanthostyle of *R. typicus* var. *stellifer*, or reduced to such an extent that the spicule is almost smooth. These extreme variations, however, form only a very small proportion of the total number of acanthostyles, the majority being definitely of the var. *stellifer* type (*vide* Hallmann, *l. c.* p. 200, fig. 41). The characters of the other types of spicules also seem to be fairly constant, so that it may be safely concluded that Hallmann was justified in distinguishing between these different varieties of the species. In fact, one may go so far as to suggest that the eight varieties of *R. typicus* (Carter) enumerated and described by Hallmann (*l. c.* vide pp. 185-6) are in reality distinct species rather than varieties. Further, the characteristic form of the toxa in the other allied species may eventually prove a sound basis for the foundation of a subgenus.

Previously known Distribution.—Bass Strait, East coast of Flinders Island (*Hallmann*).

Registered Nos. XVI, LVIII A, B & C, XXIII, XXXVI, XLIV.

10. Clathria rubens (Lendenfeld).

(For synonymy, *vide* Hallmann, 1912, p. 218.)

Two specimens, both conforming very closely to Hallmann's redescription of the holotype (*l. c.*).

Previously known Distribution.—E. coast Australia (*Lendenfeld*).

Registered No. LXIII.

11. CLATHRIA TRANSIENS Hallmann, 1912, p. 226.

The single specimen is identical with form C as described by Hallmann (*l. c.*).

Previously known Distribution.—S. coast Australia (*Hallmann*).

Registered No. LXII.

12. WILSONELLA PYRAMIDA (Lendenfeld).

Clathria pyramida Lendenfeld, 1888 A, p. 222.

Wilsonella pyramida Hallmann, 1912, pp. 240 & 244.

Hentschel (1909) considers that in all probability *C. pyramida* (Lendenfeld) is identical with *C. alata* (Dendy). Hallmann (1912) suggests that *C. alata* is a variety of *C. pyramida*, but it is doubtful if they are even varietally distinct. The differences mentioned by Hallmann as being constant and separating the two varieties proved, on examination of the British Museum specimens and comparison with the Maria Island specimens, to be merely individual variations such as one would expect to find in specimens from slightly different localities.

Previously known Distribution.—E. coast Australia (*Lendenfeld*).

Registered Nos. XXVIII, XXXV.

13. WILSONELLA DURA (Whitelegge).

(For synonymy, *vide* Hallmann, 1912, p. 242.)

This sponge is represented by a fragment which has obviously been torn off a large specimen.

Previously known Distribution.—Tuggerah Beach, N.S.W.; Australia (*Whitelegge*).

Registered No. LXX.

14. ECHINOCLATHRIA ARENIFERA Carter.

? *Halopsamma laminæfavosa* Carter, 1885, p. 212.

Echinoclathria favus var. *arenifera* Carter, 1885, i. p. 350.

Echinoclathria arenifera Dendy, 1896, p. 40.

NOTE.—This sponge agrees very closely in external form with *E. favus* as described and figured by Ridley and Dendy (1886) and Hallmann (1912). As regards spiculation the auxiliary strongyla are identical in form and size with those of *E. favus*, while the principal styli, which are very rare indeed, appear to be somewhat larger but identical in shape. Chelæ are absent, but in *E. favus* they are described as being very small, scarce, and of extreme tenuity. The correspondence in external form and spiculation indicates clearly that *E. arenifera* has been

derived from *E. favus*, and the question arises whether the inclusion of sand in the skeletal fibres and the consequent reduction of the principal megascleres is a sufficient reason for establishing a new species as proposed by Dendy (*l. c.*). If, as Carter suggests, the presence of sand is the result of a sandy habitat, the inclusion of sand may not be a constant specific character but merely a varietal character depending on the nature of the ground on which the sponge is growing.

Previously known Distribution.—Port Philip Heads, S. Australia (*Carter*, *Dendy*).

Registered No. LIII.

15. Echinochalina glabra Ridley & Dendy.

(For synonymy, *vide* Hallmann, 1912, p. 290.)

Previously known Distribution.—Moncoeur Island, Bass Strait (*Ridley & Dendy*); Port Philip (*Dendy*); S. Australia (*Hallmann*).

Registered No. XLII.

16. Echinochalina intermedia (Whitelegge).

This uncommon species is represented by a fine, erect, massive, slightly clathrate specimen.

Previously known Distribution.—Australia (exact locality of Whitelegge's specimen unknown).

Registered No. XXV.

17. Raspailia cacticutis (Carter).

This sponge is represented by five small specimens growing on a Pecten shell.

Previously known Distribution.—S. Australia (*Carter*, *Dendy*).

Registered No. XXXII B.

18. Rhabdosigma mammillata (Whitelegge).

The only hitherto known specimen of this interesting species has been fully described by Hallmann, 1916 B, p. 520, and 1917 B, p. 398.

Previously known Distribution.—N.S.W., Australia (*Hallmann*).

Registered No. LXI.

Section **Myxilleæ.**

19. Plumohalichondria purpurea Carter.

There is no trace of the purplish colour noted in the type.

Previously known Distribution.—Port Philip Heads, S. Australia (*Carter*, *Dendy*).

Registered No. XXII.

20. Orella incrustans Carter, var. digitata Hallmann, 1912. (Pl. I. figs. 3 & 4.)

Six specimens of this species are present and show considerable variation in external form. Four of the specimens (R. N. LXXIII) incrust Pecten shells (the Pecten is still within the shell), following exactly the contour of both valves. In three of the specimens the sponge is nowhere more than 5 mm. thick, but in the fourth specimen the surface becomes irregularly raised up on one part of the shell, the sponge attaining 20 mm. in thickness. These specimens differ from those described by Hallmann (*l. c.*) in the absence of long digitiform processes or branches arising from the crust, although, as mentioned above, there is in one case an attempt to form an incipient branch. The absence of these digitiform branches in the Maria Island specimens lends support to Hallmann's suggestion that this variety is identical with Carter's holotype, which is described as "massive, incrusting, covering the whole of a Pecten."

One of the other specimens (R. N. LXVII) is peculiar in shape. The lower part is massive and subspherical, measuring about 45 mm. in diameter, and from this, on the upper surface, arise elongated, cylindrical, or flattened digitiform processes, two of which branch irregularly. The longest process measures 70 mm. × 20 mm. This specimen resembles very closely those described by Hallmann. The peculiar shape of the basal spherical part and the undoubted identity of this sponge with the incrusting forms, suggested that the basal part might have completely surrounded some object on which the sponge had been growing, and on cutting this part across a very small Pecten was found embedded in the centre.

The remaining specimen (R. N. XIV) is erect, flabellately expanded and branching, the branches being irregularly cylindrical to lobose, and arising in one plane of the lamina from its apical end. This specimen resembles Hallmann's var. *arenacea* in external form, but its skeletal structure shows it to belong to var. *digitata*. This is the only known specimen of var. *digitata* which has not been found growing on a bivalve mollusc.

The skeleton in the last two specimens (R. N. LXVII, XIV) agrees very closely with Hallmann's description (*l. c.*), both as regards the arrangement of the fibres and the dimensions of the spicules. The incrusting specimens, however, show certain differences, the chief being that the accessory acanthostyles, which form so characteristic a part of the dermal skeleton in the typical specimens, are very scarce in the dermal layer—in fact, so scarce that at first sight they appear to be entirely absent. Also the accessory acanthostyles and oxea, which are so abundantly scattered between the fibres in a typical specimen, are here relatively scarce. These specimens, then, differ from the typical ones in the scarcity of accessory acanthostyles (more especially in the dermal layer) and of interstitial oxea. As if to compensate for this deficiency the oxea are particularly abundant

in the dermal skeleton. Hallmann mentions that there is considerable variation in the proportion in which the two kinds of spicule occur in the dermal skeleton.

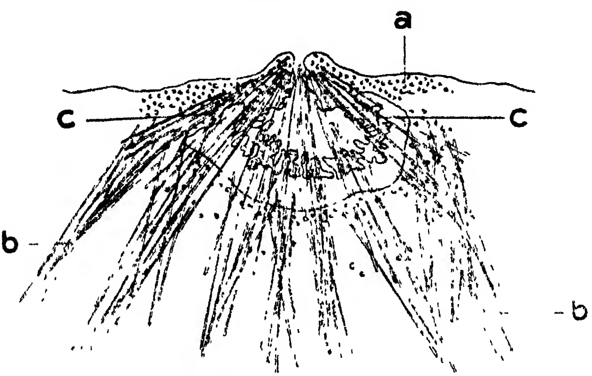
Previously known Distribution.—Oyster Bay, Tasmania (*Hallmann*).

Registered Nos. XIV, LXVII, LXXIII.

21. Hamigera dendyi, sp. n. (Pl. I. figs. 1 & 2, 7.)

The sponge is compact, erect, irregular in shape, and sessile. The greater part of the surface is covered with low rounded papillæ, about 1 mm. apart, each bearing a single large "pore" at the apex. These were at first thought to be dermal pores,

Text-figure 1.



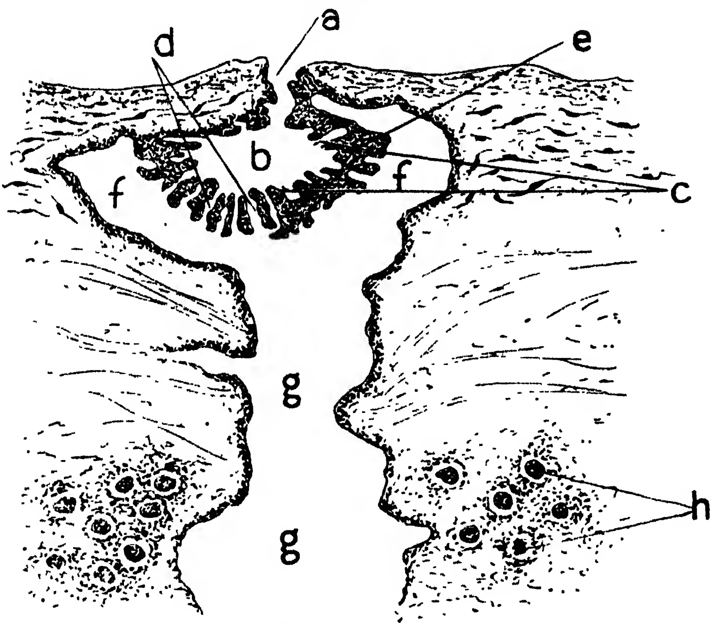
Hamigera dendyi, sp. n.

Diagrammatic vertical section through one of the pore areas, showing the arrangement of the skeleton in that region. *a*. Dermal layer of tridentate isochelæ. *b*. Choanosomal fibre of strongyla and subtylostrongyla. *c*. Dermal bundles of similar spicules converging towards the "pseudopore" or opening of the porocalyx.

but from further investigation it seems likely that they are the openings of "porocalices" or sunken pore areas, and that the true dermal pores lie at the bottom of these cup-like depressions. Contraction on preservation has caused the porocalices to resemble inhalent canals. Oscula are fairly numerous and occur at the apices of papillæ, which are much larger than those bearing the "pores," and are grouped towards the distal end of the sponge. The dermal membrane is glabrous, moderately thick, and easily separable from the underlying tissue. The consistency is soft, compressible, and fairly resilient, and the colour, in spirit, pale yellowish brown. The specimen measures 50 mm. in height and 20 mm. in average diameter.

The skeleton of the choanosome consists of a rather loose, irregular reticulation of ill-defined spicular fibre and single scattered spicules. Near the surface the arrangement becomes more regular; the fibres are better defined and run perpendicular to the surface, branching dendritically and ending in numerous vertical tufts just under the dermal membrane. In the region of the papillæ these tufts flatten out and converge towards the apex of the papillæ (text-fig. 1), so that in surface section they

Text-figure 2.



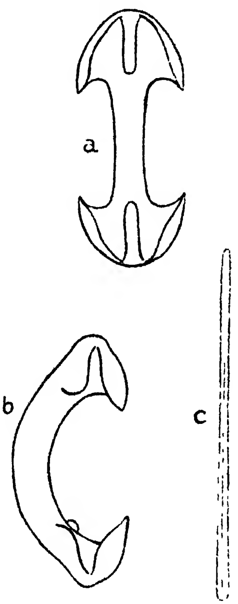
Hamigera dendyi, sp. n.

Diagrammatic vertical section through one of the pore areas, showing the soft tissues and the canal system. *a*. Pseudopore. *b*. Porocalyx, at the bottom of which lie the dermal pores (*c*) leading into narrow canals (*d*) which run through a plug of tissue (*e*) and open into a large subdermal cavity (*f*). *g*. Inhalent canal. *h*. Flagellate chamber.

appear to lie horizontally and form circular systems round the pore areas (text-fig. 4). By far the greater part of the spicules composing the spicular fibres are subtylostrongyla or strongyla (text-fig. 3 *c*), true styli being very rare and occurring only in the deeper parts of the choanosome. Tridentate isochelæ are scattered in the choanosome and are much more numerous towards the surface and in the walls of the canal system than elsewhere.

The dermal skeleton consists of radial systems of subtylostrongyla and strongyla surrounding the pores and lying tangentially in the dermal membrane (text-figs. 1 & 4) as described above. These systems, which give the surface a very regular and beautiful appearance, measure 1·5 mm. in diameter and are ·5 mm. apart. Very numerous tridentate isochelæ (text-figs. 3 *a* & 3 *b*) are scattered densely both in and between the pore areas and form a dermal layer ·25 mm. thick.

Text-figure 3.



Hamigera dendyi, sp. n.

a. Tridentate isochela. × 2280. *b*. Ditto, side view.
c. Subtylostrongyla. × 260.

The structure of the pore areas is very striking. In vertical section (text-fig. 2) the pseudopore is seen to lead into a relatively wide canal which runs down through the dermal cortex and opens into a cavity which lies in the centre of a plug of very dense tissue. The canal and central cavity probably represent a porocalyx with the part lying just below the dermal membrane very much contracted. From this central cavity numerous small canals run through the substance of the plug and open into a large subdermal cavity from which the inhalent canals lead off. The openings of these small canals into the central cavity represent the true dermal pores.

Megascleres.

1. Subtylostrongyla or strongyla. Smooth, slender, straight, ends usually slightly unequal. One end rounded off and the other slightly swollen, or both ends simply rounded off. ·360 mm. × ·003 mm. – ·004 mm.

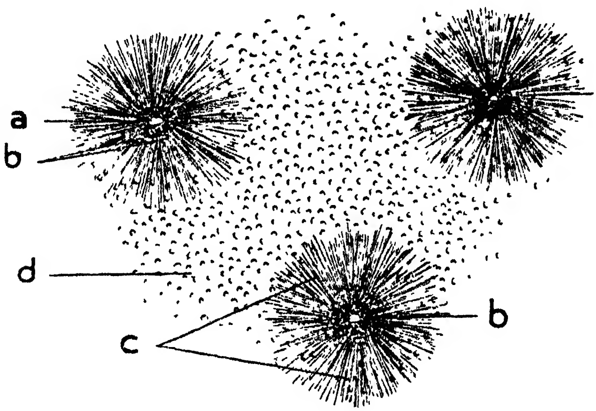
2. Styli. Smooth and straight. ·245 mm. × ·007 mm.

Microscleres.

Tridentate isochelæ. ·029 mm. in length. Of the usual type, with very stout strongly curved shaft and short teeth.

This species closely resembles *Hamigera papillata* Dendy, but differs from it in the much greater regularity of the dermal

Text-figure 4.



Hamigera dendyi, sp. n.

Diagrammatic representation of part of the surface showing pore areas. *a.* "Pseudopore." *b.* Plug of tissue. *c.* Dermal bundles of spicules lying in the pore areas and converging towards the "pseudopore." *d.* Dermal layer of tridentate isochelæ.

skeleton round the pore areas and the greater scarcity of styli. On comparison the two specimens were seen to differ considerably in external form.

It is somewhat doubtful if, in the almost entire absence of monactinal megascleres in the main skeleton, this species should be included in the genus *Hamigera*. The skeleton, however, only differs from that of a typical *Hamigera* in that the dermal symmetrically or subsymmetrically-ended megascleres have almost entirely replaced the monactinal in the formation of the main skeleton. In view of the existence of such species as *Hamigera papillata*, in which the styli occur only in the deeper parts of the sponge, and the fact that the chelæ of *H. dendyi* and *H. papillata* are identical, it seems advisable for the present to include this species in the genus *Hamigera*.

Registered No. LIX.

Section **Phoriosponginea.**

22. Phoriospongia kirkii (Carter).

Phoriospongia kirkii Dendy, 1924 A, p. 363.
(For further synonyms and literature, *vide* Dendy, 1916 A.)

This very common Australian species is represented by five specimens, all of the typical form.

The skeleton of these sponges is interesting in that it shows a great amount of variation in the extent of the reduction of the proper skeleton and its replacement by sand and foreign bodies. The main skeleton is an irregular subrectangular reticulum with the primary fibres (where distinguishable) stouter than the secondary. Three of the present specimens agree in having the main skeleton fibres very clearly defined, and in these the fibres are composed entirely of foreign spicules. In the other two specimens the fibres are very irregular and ill defined and extremely sandy. The megascleres proper to the sponge are strongyla and are scattered irregularly between the fibres. In three of the specimens they are very numerous, while in the other two they are rare. As regards the microscleres, two specimens have very numerous sigmata scattered in the ground tissue, while in the other three specimens none appear to be present. Two of the specimens with no sigmata are ones in which the strongyla are rare, but that this connection does not necessarily exist is shown by R. N. LXXV, in which there are no sigmata but numerous strongyla.

In R. N. XV the dermal skeleton is composed of radial tufts of strongyla, which project through the dermal membrane, giving the surface a hispid appearance. These strongyla are much thicker and better developed than those in the interior of the sponge. In all the other four specimens the dermal skeleton is composed of a close meshed network of fibres which are very densely packed with foreign spicules, and very few, if any, dermal strongyla are present. The former type of dermal skeleton is undoubtedly that proper to the sponge, the latter a stage in the reduction.

Thus R. N. XV has the most complete skeleton, a true dermal skeleton being well developed and strongyla and sigmata both numerous in the choanosome. The replacement of the dermal skeleton of strongyles by sand and foreign spicules, the partial loss of choanosomal megascleres, and the complete loss of microscleres are stages in the reduction of the true skeleton, and, presumably, are due to the inclusion of sand and foreign bodies.

Previously known Distribution.—Australian Seas (*Carter, Lendenfeld, Dendy*); Indian Ocean, Okhamandal (*Dendy*); North Cape, New Zealand (*Dendy*).

Registered Nos. VII, LII, XV, LXXV.

Section **Tedanieæ.**

23. TEDANIA COMMIXTA Ridley & Dendy.

A single massive oval specimen.

Previously known Distribution.—Bass Strait (*Ridley & Dendy*); Port Philip Heads (*Dendy*); Azores (*Topsent*).

Registered No. X.

24. TEDANIA DIGITATA (Schmidt).

This common and cosmopolitan species is represented by two specimens, both of which belong to the typical variety.

Previously known Distribution.—Almost cosmopolitan.

Registered Nos. XLVI, XXVII.

Subfamily AXINELLINÆ.

Section **Axinelleæ.**

25. PHAKELLIA FLABELLATA Carter.

Phakellia flabellata Carter, 1885, i. p. 363.
Phakellia crassa Carter, 1885, i. p. 363
Phakellia brassicata Carter, 1885, i. p. 363.
Phakellia villosa Carter, 1886, p. 379.
Reniera vasiformis Carter, 1886, i. p. 445.
Phakellia flabellata Ridley & Dendy, 1887.
Reniera brassicata Carter & Dendy, 1895, p. 236.

The five specimens representing this species range from simple flabellate expansions through flabellate expansions folded round so as to form a more or less complete cup, to complete cup-shaped forms with a distinct stalk.

An interesting case of synonymy was brought to light by a study of the skeleton. The arrangement of the skeleton agrees very closely with the descriptions given by Carter and Dendy (*l. c.*), but the form of the spicules composing the fibres varies in the different specimens In two of the sponges (R. N. XXXIV & XXVI) the spicules composing the plumose columns of the main skeleton are mostly styli, in another (R. N. LX) the styli are very rare, occurring only towards the surface, and oxea are the chief skeletal spicule, while in the two remaining specimens (R. N. XLVIII & XII) the skeleton is composed entirely of oxea, styli being altogether absent.

In the specimens with styli as the chief constituent of the skeleton the oxea are, on the whole, short and stout, and have a decided bend or "kink" in the centre. In the forms in which the whole skeleton is composed of oxea these spicules are very variable, the short type being present and also longer, more slender ones, which are curved but have no decided "kink" in the centre. The larger oxea are, as a rule, present in greater numbers than the short type, although the two types are not at

all clearly defined and are connected by innumerable intermediate forms.

The specimens in which the skeleton is composed entirely of oxea agree very closely with the description of *Reniera brassicata* Carter (*l. c.*), and Dendy notes that the "plumose primary lines of the skeleton (in *R. brassicata*) are suggestive of an Axinellid affinity." An examination of Carter's preparations of *R. brassicata* showed that there is no definable difference between it and the present specimens. In view of the close correspondence in external form, arrangement of skeleton, and form of the oxea, *R. brassicata* (and its synonyms) may be regarded as a synonym of *Phakellia flabellata*.

Previously known Distribution.—S. Australia (*Carter*, *Dendy*).

Registered Nos. XXVI, XXXIV, LX, XLVIII, XII.

Family Clavulidæ.

Subfamily Spirastrellinæ.

26. Sigmosceptrella fibrosa Dendy.

One small specimen of this interesting species is present.

Previously known Distribution.—Port Philip Heads, Australia (*Dendy*); Abrolhos Islands, W. Australia (*Dendy & Frederick*).

Registered No. LXIV.

Subfamily Suberitinæ.

27. Suberites carnosus Johnston.

Of this common and widely distributed species there are three specimens, one large specimen having the characteristic globular to fig-shaped external form, and two much smaller cylindrical specimens growing on a Pecten shell.

Previously known Distribution.—British Isles (*Johnston*, *Bowerbank*); Azores (*Ridley & Dendy*); Fernando Neronha (*Ridley & Dendy*); Kerguelen (*Carter*); S. Australia (*Carter*); Port Jackson (*Ridley*, *Ridley & Dendy*).

Registered Nos. LXXI, XXIV.

28. Suberites antarcticus Carter.

Two specimens agreeing very closely with the holotype and 'Challenger' specimens.

Previously known Distribution.—Antarctic Seas (*Carter*, *Topsent*); Kerguelen (*Ridley & Dendy*).

Registered Nos. XXXI, XXXIX.

29. Suberites caminatus Ridley & Dendy. (Pl. I. figs. 5 & 6.)

Suberites caminatus Ridley & Dendy, 1886 A & 1887 A, p. 119.
? *Suberites caminatus* var. Ridley & Dendy, 1887 A, p. 199.
? *Suberites microstomus* Ridley & Dendy, 1887 A, p. 199.

There are two sponges present in the collection which appear to be intermediate between *S. caminatus* and *S. microstomus*, which were originally included by Ridley and Dendy in the same species.

One of these is in the form of a smooth, pale white, rounded mass, now free, but probably originally attached by the entire lower surface. In the centre of the upper surface is a group of twelve minute oscula, each situated at the apex of a thick-walled papilla 1–2 mm. high. The sponge is strongly corticate and the texture firm and compact. The external form of this sponge is almost identical with that of the 'Challenger' specimen of *S. microstomus*, as also is the form of and arrangement of the dermal pores, the poral areas being circular in outline and not stellate, as in a typical *S. caminatus*. The arrangement of the skeleton, however, resembles that of *S. caminatus*, the dermal cortex being wide and the spicules stout with very well-developed heads. The differences between *S. caminatus* and *S. microstomus* are stated to lie in :—

1. The oscular tubes :
2. The width of the dermal cortex ;
3. The size of the spicules.

In the present specimen the oscular tubes are similar to those of *S. microstomus*, while the characters of the skeleton are those of *S. caminatus*.

The other sponge is represented by about two dozen specimens all growing on Pecten shells. They vary somewhat in shape and size, but all agree in being roughly circular in outline, attached by a broad flat base, and having a single oscular chimney in the centre of the upper surface. Young specimens are subspherical in outline and have the osculum on a level with the surface, or the oscular projection only slightly developed. These specimens measure about 5 mm. in diameter and 4 mm. in height. The remaining specimens vary in diameter from 10–40 mm., but are much flattened, never attaining a height of more than 3–4 mm. In these the oscular tubes resemble those of *S. caminatus* in being well developed, but they are thick-walled as in *S. microstomus* and not frilled at the apex. In one specimen there are five smaller projections grouped round the central one, and this gives it an appearance very similar to that of the Maria Island specimen of *S. caminatus* described above, but the smaller projections do not seem to be pierced by oscula. In all the large specimens a thick layer of sand is developed in the outer cortex so that a clear area of only about 5 mm. in diameter is left in the centre, surrounding the osculum. The three young

specimens are quite free from sand. In two cases the sponges lie very close together in groups of 3–4, so that it is probable that colonies are formed by lateral budding (*vide* Ridley & Dendy, 1887 A, p. 199). In this sponge the external form agrees more closely with the description of the holotype of *S. caminatus*, but the arrangement of the skeleton is that described as typical of *S. microstomus*.

The two species are undoubtedly very nearly related, and it is possible that with more abundant material a series of forms of them might be found. In any case, the facts indicate that the two sponges are probably at the most varietally distinct as was originally suggested by Ridley & Dendy.

Previously known Distribution.—Marion Island (*Ridley & Dendy*); between Kerguelen and Heard Islands (*Ridley & Dendy*); N. & S. Atlantic.

Registered Nos. LXVI, LXVIII A, XXXII A.

30. Suberites difficilis Dendy, var.

This species is represented by a wedge-shaped piece of a very large massive sponge.

Previously known Distribution.—Port Philip Heads (*Dendy*).

Registered No. VIII.

31. Polymastia craticia Hallmann, 1912.

This species was hitherto only known from a single specimen from New South Wales.

Previously known Distribution.—N. S. W., Australia.

Registered No. XXIX.

Order EUCERATOSA.

Family Darwinellidæ.

32. Dendrilla cavernosa Lendenfeld.

One specimen.

Previously known Distribution.—Australian Seas: W. coast, Fremantle (*Brit. Mus. Coll.*); E. coast, Port Jackson (*Lendenfeld*); S. coast, Port Philip (*Lendenfeld*).

Registered No. LXIX.

Family Spongelidæ.

33. Spongelia elastica Schulze, var. crassa Dendy.

One perfectly typical specimen of this variety.

Previously known Distribution.—Gulf of Manaar, Ceylon (*Dendy*).

Registered No. XXI.

34. SPONGELIA ELEGANS Nardo.

Previously known Distribution.—Mediterranean (*Nardo, Lieberkühn, Kölliker, Schmidt, Schulze*); Australian Seas (*Lendenfeld*).

Registered Nos. XLIX, XI.

35. SPONGELIA HIRCINIFORMIS (Carter).

One fine specimen.

Previously known Distribution.—S. coast Australia (*Carter*); N. Cape, New Zealand.

Registered No. XLI.

Family SPONGIIDÆ.

36. LEIOSELLA ILLAWARRA Lendenfeld. (Pl. I. fig. 8.)

One specimen of this very beautiful and interesting species.

Previously known Distribution.—Illawarra, N.S.W., Australia (*Lendenfeld*).

Registered No. XXXVIII.

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EXPLANATION OF THE PLATE.

Fig. 1. *Hamigera dendyi.* Photograph of a vertical section similar to those illustrated in text-figs. 1 & 2.

2. *Hamigera dendyi.* Photograph of the surface, showing single-pore area.

Figs. 3 & 4. *Crella incrustans* var. *digitata*, showing variation in external form. ½ nat. size.

Fig. 5. *Suberites caminatus.* Nat. size.

6. "*Suberites microstomus.*" ½ nat. size.

7. *Hamigera dendyi.* ½ nat. size.

8. *Leiosella illawarra.* ½ nat. size.

26. A New Genus of Chætopteridæ from the N.E. Pacific: with some remarks on allied genera. By EDITH BERKELEY, The Biological Station, Nanaimo, B.C. *

[Received December 23, 1926: Read April 26, 1927.]

(Text-figures 1–3.)

Introduction.

The species of Chætopteridæ which is the subject of this paper was first recorded and partially described but not named by Potts (1). It was attributed by him to the genus *Telepsarus* Gabr. Costa.

I have collected the animal in two of the localities in which Potts found it and in many others within a radius of about twenty miles of Nanaimo. As he points out, it is one of the commonest tubicolar polychætes of the beaches in the neighbourhood; it may, in fact, be found in almost any spot where a stretch of clean sand is left exposed at low tide. Potts's description of the habitat of the animal, its tube, its association with *Mesochætopterus taylori*, and of such features of its external anatomy as he was able to characterize from the imperfect specimens at his disposal, place the identity of his species and mine beyond possibility of doubt. There is, moreover, nothing else in the least like it to be found in the localities indicated. Examination of complete specimens make it clear that it cannot be included in the genus *Telepsarus*, nor indeed in any existing genus of Chætopteridæ. I have therefore based a new genus on the material.

LEPTOCHÆTOPTERUS, gen. n.

Chætopteridæ with the body divided into three regions, the median of which has a large number of segments which bear bilobed notopodia. The peristomium carries only one pair of tentacles.

LEPTOCHÆTOPTERUS POTTSI, sp. n.

It is extremely difficult to obtain entire specimens of this worm and to preserve it in such a way as to make examination easy. It inhabits a tube which runs vertically through the sand, is annulated at short intervals, and is easily ruptured at any of the annulations. At the approach of danger the animal descends rapidly in its tube, and usually succeeds in breaking through at one of these points well below the surface and extruding the

* Communicated by C. C. A. MONRO, M.A., F.Z.S.

hinder portion of its body through the rupture. The extruded portion is then readily cut off by the sharp edge of the tube and lost. The severance usually takes place anteriorly to the posterior region of the body, and it was, no doubt, due to this having occurred that this region was entirely lacking in Potts's specimens. I had myself frequently failed in the same way to obtain the posterior region before I succeeded in securing a specimen which had broken within that region and had a few of the posterior segments attached. By very careful digging I eventually succeeded in securing the entire animal.

It is necessary to extract it from its tube before fixing since, as Potts points out, the tube is very impermeable to fixative. It is, moreover, advisable to keep it extended in some way, such as wrapping it round a card or microscope-slide, before fixing, otherwise contraction is so vigorous that it becomes practically impossible to examine satisfactorily when fixed.

The length of the type-specimen, the longest complete individual examined, was 63 cms. when alive and within its tube, the width at the widest point about 2 mm. The tube measured 98·5 cms. When fixed the animal measures 48 cms.. of which the anterior region makes up 1 cm., the median region 7 cms., and the posterior region 40 cms.; the median region has, however, contracted considerably more than the rest. Several specimens have been obtained with measurements approximating to these. On the other hand, four specimens obtained together in one locality are considerably smaller and have 34, 40, 44, and 54 segments respectively in the median region.

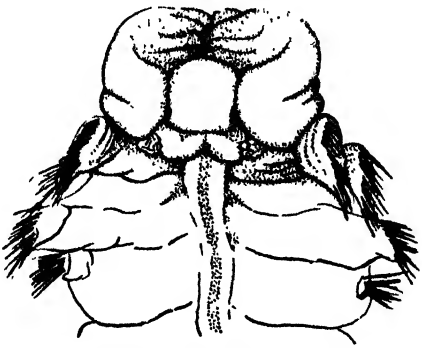
The prostomium is a well-defined knob-like process the diameter of which is about a quarter the width of the body. It bears laterally a pair of large black eyes which are usually almost completely hidden by the projecting portions of the peristomium and by the tentacles. The peristomium projects slightly beyond the prostomium forming a collar which, as seen dorsally, has the outline of a horseshoe; the prostomium is seen through the open portion of the shoe. The peristomium bears a pair of long (about 30 mm. in the type), delicate, grooved tentacles which are attached just below the points at which the peristomial collar meets the prostomium. There is absolutely no trace of a second pair of appendages, such as occurs in *Phyllochætopterus*, in any of the numerous specimens examined. A ciliated groove starts midway between the bases of the tentacles and continues along the whole length of the dorsum, as in *Phyllochætopterus* (text-fig. 1).

The remainder of the anterior region consists of nine setigerous segments. These segments are adequately described by Potts (1, p. 970). In general form they resemble very closely the corresponding segments in *Telepsavus costarum* as described and figured by Claparède (2, p. 34, and pl. xx. fig. 1), the eighth and ninth segments being markedly longer than the rest. I have nothing to add to Potts's description of the setæ of this region.

The median region in the type consists of 84 segments, but

in other individuals, in which an exact count is difficult owing to their contracted state, even more than this number seems to occur. The general character of these segments is well described by Potts, but he did not observe the glandular papillæ on the

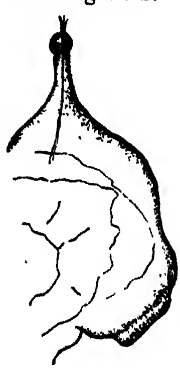
Text-figure 1.



Leptochætopterus pottsi, gen. n., sp. n.
Dorsal view of the prostomium, peristomium, and first four setigerous segments. The tentacles have been removed. × 14.

dorsal surface similar to those described in the case of *Telepsavus costarum* by Claparède (2, p. 344, and pl. xx. fig. 1*d*). I find these on all the segments of this region, though they are made out with difficulty towards the posterior end of it.

Text-figure 2.



Leptochætopterus pottsi, gen. n., sp. n.
A parapodium from the posterior region. × 20.

The posterior region consists, in the type, of 237 segments, but the number is extremely variable in individual specimens. The general aspect of the region is exactly like that of the

corresponding region in *Phyllochætopterus.* The notopodia are represented by elongated cylindrical processes slightly flattened and expanded at the tips, as is described and figured in the case of *Phyllochætopterus socialis* by Claparède (**2**, p. 347, and pl. xxi. fig. 1 C), but, unlike that species and others of the genus of which I have knowledge, they bear two or three setæ instead of only one (text-fig. 2). The setæ are more delicate, but in general shape similar to those of the anterior region. The neuropodia are represented by small flaps which bear transparent, striated hooks similar to those described and figured in the cases of *Spiochætopterus typicus* and *Phyllochætopterus anglicus* by McIntosh (**3**, pp. 475 and 477; pl. 138. fig. 14 and pl. 136. fig. 12*a*), and in that of *Phyllochætopterus fallax* by Claparède (**2**, p. 351 and pl. xxi. fig. 2 B) (text-fig. 3). The pygidium in the type seems to be partially retracted, in which state the body terminates in two equal lobes with the anus situated nearer the dorsal than the ventral surface. In other specimens the pygidium is represented by no more than a turgid ring thicker on the ventral than the dorsal side.

Text-figure 3.

Leptochætopterus pottsi, gen. n., sp. n.
Hooks from the neuropodium of a posterior segment. × 200.

The general body colour of the animal in life is a pale fawn. The prostomium is usually unpigmented, but occasionally has a few mottlings of faint brown. The peristomium is covered with blotches of a darker brown. The tentacles are pinkish-brown, the pigmentation being most intense in the ciliated grooves. The remaining segments of the anterior region are unpigmented on the dorsal side. On the ventral side there are mottlings of dark brown pigmentation as far as the seventh setigerous segment, where they culminate in a densely pigmented area. An intensely white shield-shaped patch extends from this segment to the ninth covering the sides as well as the ventral surface proper. From the ninth segment rearward the green colour of the gut is seen through the body-wall producing a general greenish tinge which is most intense in the posterior region. In ripe females, taken in April, this is mottled with the orange colour of the ova within.

The Relation of Leptochætopterus *to Allied Genera.*

The recognition that the species under consideration has the body divided into three distinct regions makes it impossible to

include it in the genus *Telepsavus* for this genus, together with *Ranzania*, is definitely separated from the other genera of Chætopteridæ by the absence of the third region. Of the remaining four genera three, *Chætopterus*, *Spiochætopterus*, and *Mesochætopterus*, have a limited and small number of segments in the median region, which fundamentally differentiates the present species from them.

There remains *Phyllochætopterus*. In this genus, as originally defined by Grube, the number of segments in the median region is not specified, and Claparède's amended definition (2, p. 344) does not touch on the point. In the original definition only one pair of tentacles is said to occur, but Claparède points out that the Phyllochætopteridæ have two pairs, a long pair and a pair of setigerous peristomial appendages. This amendment has since been generally accepted. It would therefore be possible to include the present species within the genus *Phyllochætopterus* only by reverting to the original definition, in which case another name would be necessary for the several species included within that genus to-day. This seems undesirable, and I have therefore judged it best to found a new genus on the present species.

There remains, however, one further possibility. The two anterior regions of the species here described resemble very strikingly the species which have been included in the genus *Telepsavus*. They agree, in fact, very closely with the description of *Telepsavus costarum* given by Claparède (2, p. 340), and I should certainly have classified the form in question as that species had I not found the posterior region. It is readily understandable how, in the absence of that region, Potts placed it within the genus. Seeing how easily the animal splits off this region of the body and having regard to the fact that no description of a pygidium, or other evidence of the completeness of the specimens examined, has been given by the authors who have dealt with the genus *Telepsavus*, is it not possible that the posterior region has been overlooked in the same way as it was originally missed in the present species? It would seem highly desirable that the species which have been attributed to the genus *Telepsavus* should be collected again with great care and be examined from this point of view.

Literature.

(1) Potts, F. A.—Polychæta from the N.E. Pacific: The Chætopteridæ. With an account of the phenomenon of asexual reproduction in *Phyllochætopterus* and the description of two new species of Chætopteridæ from the Atlantic. Proc. Zool. Soc. London, 1914.

(2) Claparède, E.—Les Annélides Chétopodes du Golfe de Naples. Geneva, 1868.

(3) McIntosh, W. C.—A Monograph of the British Marine Annelids. Vol. iv. Pt. 2. London, 1922–1923.

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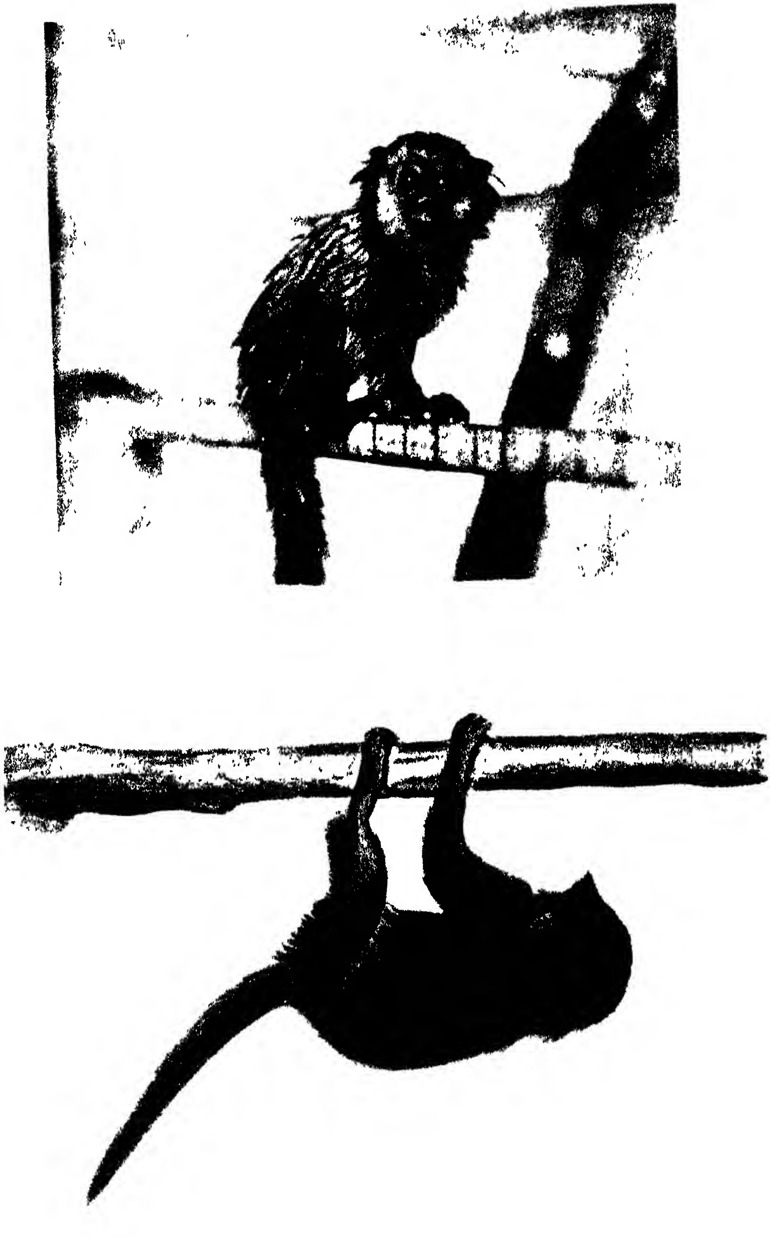
BREEDING OF THE COMMON MARMOSET (<u>HAPALE JACCHUS</u> LINN)
IN CAPTIVITY



BREEDING OF THE COMMON MARMOSET (HAPALE JACCHUS LINN)
IN CAPTIVITY

27. On the Breeding of the Common Marmoset (*Hapale jacchus* Linn.) in Captivity when irradiated with Ultra-violet Rays. By N. S. LUCAS, B.M., F.Z.S., Miss E. MARGARET HUME, and Miss H. HENDERSON SMITH, from the Lister Institute.

[Received February 1, 1927: Read March 8, 1927.]

(Plates I. & II.*)

Many efforts have been made to keep the Common Marmoset (*Hapale jacchus* Linn.) in captivity in this country, but on the whole with very poor success. It is now known that the failure is mainly due to the extreme susceptibility of these creatures to rickets, whether they are kept as private pets or as inhabitants of menageries. The disease usually takes the form, common in human beings, of softness of the bones, leading to all the common deformities. Sometimes a form of the disease occurs in which rigidity is the prominent feature. The end is the same in either case; the animal dies of an intercurrent complaint, or has to be chloroformed to put an end to its sufferings. At *post-mortem* examination there is almost invariably evidence of extreme constipation, due to loss of muscular tone of the bowel.

Since the Common Marmoset is so subject to rickets, it is clear that in attempting to keep or breed these creatures it is of particular importance to make use of some adequate form of anti-rachitic treatment. Cod-liver oil has often been tried already, but its use has proved impracticable owing to the animal's dislike to it. An alternative is artificial sunlight, and its use was determined upon in the present case.

In the first instance it was sought to make a comparison between the welfare of a marmoset kept over a considerable period and treated with artificial sunlight and that of another marmoset kept in exactly similar conditions, but without the artificial sunlight. Two male marmosets were therefore bought from a dealer in the first week of October 1925. One was fully adult and weighed 360 gms., the other was almost adult and weighed 250 gms. It was decided that the larger and older one should be used as the untreated control, and that the younger one, which by reason of its age would probably be more susceptible to rickets, should receive artificial sunlight.

The light was given by means of a mercury-vapour quartz arc which was somewhat deteriorated by constant use, and in consequence had the advantage of not causing conjunctivitis in the

* For explanation of the Plates see p. 451.

unshielded eyes of the marmoset. The animal was carried along in its cage and placed at a distance of about 15 inches below the lamp. The exposure was usually for ten minutes, and took place every week-day. The irradiation, probably owing to the concomitant warmth, seemed to afford the creature great comfort, and it usually hung from the cage, with the face turned away from the light, letting the rays fall on its relatively hairless belly.

The staple diet was banana and boiled milk sweetened with sugar. This, with the addition of a few meal-worms and grapes, has been also the staple diet of all the marmosets referred to in this note. The older male marmoset never accepts meal-worms, which is most unusual in a marmoset. The cage was kept in a warm and rather stuffy room.

The irradiated marmoset remained in perfect health throughout the winter and right up to the present time. In the first two months after irradiation started, it changed its coat, and again in July and August 1926. It was very noticeable that, whereas most marmosets in captivity sooner or later lose the hair on their tails, which then become partially or quite bald and rat-like, in the present instance the hair was completely regained, and the coat came into perfect condition. This animal, which was the tamer of the two marmosets, was allowed its liberty for a short time each day. At these times it showed itself capable of prodigious leaps; one which was measured proved to be ten feet in length.

The older control marmoset, after a period of five and a half months, in February 1926, showed loss of appetite, roughness and poverty of the coat and slight loss of activity; the hair on the tail was gradually lost and not regained. As it was not desired to lose him, light treatment was administered, as to the other marmoset, with beneficial results; the coat was lost and then fully restored, and the animal has been preserved in health right up to the present time. It would appear that loss of coat and subsequent restoration of it are the usual sequelæ in marmosets when light treatment is instituted, as the same process was also observed in the case of the female marmoset, which will be referred to shortly.

As it was considered that success had been so far attained in maintaining the marmoset in health by the use of ultra-violet light, it was determined to make a more ambitious experiment and try to breed them. On March 10th, 1926, a large adult female was accordingly purchased from a dealer. The weight on that day was only 270 gms., but the creature was obviously under-nourished, and in eighteen days she put on 50 gms., weighing on April 1st 320 gms. and on April 15th 335 gms. Irradiation, as previously described, was begun at once, and after three days' quarantine, on March 16th she was put into the same cage with the two male marmosets. During the ensuing week it became obvious that the two males were rivals. Each time

the younger male approached the female he was driven off by the older, and when it was clear that the female acquiesced in the elder male's appropriation of her, the younger male was removed to a separate cage. On March 23rd coitus was observed, and also on the next two or three days. Then attempts became fewer and less acceptable to the female, and finally ceased altogether. During the ensuing months there were no signs of œstrum, and when the young male was at liberty he paid no more attention to the female, through the bars of the cage, than he did to the other male. On the 23rd of June the female's weight had risen to 405 gms., and on the 12th of July further to 420 gms. During the last week of July an enlargement of the female's breasts was detected and the body was distinctly stouter, but it was impossible to diagnose pregnancy with certainty. Early in August the abdomen became more enlarged and the skin over it became darker-coloured; pregnancy then seemed certain.

In the night of August 19–20 twins were born, and the period of gestation would therefore appear to be about 150 days. On the morning of August 20th only one young one was at first seen, and it was lying dead on the floor of the cage; the mother obviously had no live baby clinging to her. Later in the day, however, on looking at the male marmoset, a baby was detected, nestling in his fur and clinging to his side between the fore and hind limbs. The little one was well furred and of a greyish colour, with a long beautifully ringed tail. A dark brown stripe ran from between the eyes, backward down the centre of the scalp, almost to the nape of the neck. The hair about the eyes was of the same dark brown colour, and the eyes themselves were large, and so dark brown that iris and pupil were indistinguishable, giving to the little creature almost the look of a nocturnal animal. It was, however, more monkey-like in appearance than is an adult marmoset. It was not possible to weigh the living baby, but the weight of the dead one was found to be 30 gms. The dead baby was a male; the living one is believed to be a male, but careful examination has not been possible. The placenta was recovered intact, the female having shown no inclination to eat it

Careful observation was maintained, in spite of the nervousness of the parents, and it was seen that the mother only received the baby in order to suckle it, which she did about every 2–3 hours throughout the day. She would approach the father and hold out her arm, when the baby would scramble, apparently spontaneously, on to her. After the feeding was over she would pull the baby off and give it to the father, who would take it and tuck it back on his flank. As the baby grew heavier, it seemed to prefer to hold on higher and higher up the father's side, until it came at last to sit on his back, just across the shoulders. At seventeen days the young one was first seen to leave the parents for short periods, holding on to the bars of the

cage near to them. At four weeks it could move about quite freely, though a little shaky on its legs; but at this time and for many weeks afterwards it instantly leapt on to the back of one of the parents at the smallest alarm. At about the age of seven weeks a period began when the father seemed to tire of carrying it; he would gently bite its fingers, push it off with his paws or, when it got out of reach, try to rub it off against the cage-bars. He would also refuse to relieve the mother of it; she would obviously entreat him to take it, and he would refuse, whereupon she would gently box his ears and proceed to divest herself of the little one as best she could. The baby was apparently entirely fed by the mother for the first three weeks; at that age it was first seen to take banana from the hands of the parents, but it was several days later before it appeared actually to eat it. At five weeks it was seen to drink milk from the dish, hanging from the perch by its feet in order to drink, just as the parents do. Weaning was a very gradual process, but seemed to be complete at about the age of six weeks, and the baby would then help itself freely to food out of the dish, and seemed able to be independent, though the mother would allow it to come on her back when it was frightened, and it is believed that it always slept there.

During the eleven weeks of life thus far observed, the infant did not change greatly in colouring or appearance. The fur on the back became less grey and much more yellow, and very small dark ear-tufts appeared. The skin of the face remained dark, but the iris of the eye was, at the eighth week, somewhat lighter in colour, so that the pupil could be distinguished.

There are records that marmosets have been born in this country, but none have been found of one's surviving as long as this one and thriving in the way that it has done. The writers have no doubt that their success is due to an adequate provision of ultra-violet light, from an artificial source, to replace the brilliant sunshine of Brazil to which these little creatures are adapted. Neither fresh air nor opportunities for much exercise were available in the present case, so that it is clear that the key to the situation does not lie in the provision of them, but rather in proper and adequate anti-rachitic treatment.

The writers are indebted to the Lister Institute for the provision of every necessary facility, and to the Medical Research Council for in one case a whole-time and in another case a half-time grant for salaries.

ADDENDUM.

Pairing had again been observed on September 16th, 1926, and on February 4th, 1927, another pair of twins was born, of which again one was dead. The gestation period was 142 days. The placenta on this occasion was not to be found, and about one day after parturition the female passed almost black fæces, suggesting that it had been eaten.

The previous young one was not removed, and at first showed very little curiosity about the new baby. On the second day, however, it took it and carried it about for a short time, but soon got tired of it and tried to brush it off. This upset the father, who refused to take it, and it was left hanging to the top of the cage, screaming vigorously. Owing to this it was possible to see it more clearly. It was of dark colour, especially on the top of the head and shoulders. There were traces of a tawny undercoat. The throat and abdomen were relatively bare of fur and reddish, while the soles of the feet were a deep red. The tail was strongly marked in rings of dark and light grey.

It became necessary to separate the previous young one. This was done, and both parents were much agitated, especially the male. It was then taken to another room, where it moped. The other pair of young marmosets in the adjoining cage were then removed to the same room with it, and this caused them to mope. Also the mother of the baby, who apparently had previously taken no notice of her neighbours, was much agitated at their absence and refused to carry her baby, passing it to the male, who promptly passed it back. The baby was being so neglected that, as a final experiment, the young pair were brought back and the former baby placed with them. A vigorous game of play began at once, and the mother, with her baby upon her flank and the father beside her, sat down at once on a perch and watched it with evident satisfaction. Since then, although the father, except in the late afternoon, seems reluctant to have the baby, conditions have been peaceful. The baby seems more active than the former one and less inclined to stay in one place. This annoys the mother, who appears to bite it and try to push it back to the position she wants it.

The former baby has now grown to a weight of 270 grms. The iris is now evidently brown and the white mark on the brow is well marked. The fur is still a much lighter grey than the adult. The bars on the lumbar region are making their appearance. The ear-tufts are sprouting and have a white sheen, but are not definitely white.

EXPLANATION OF THE PLATES.

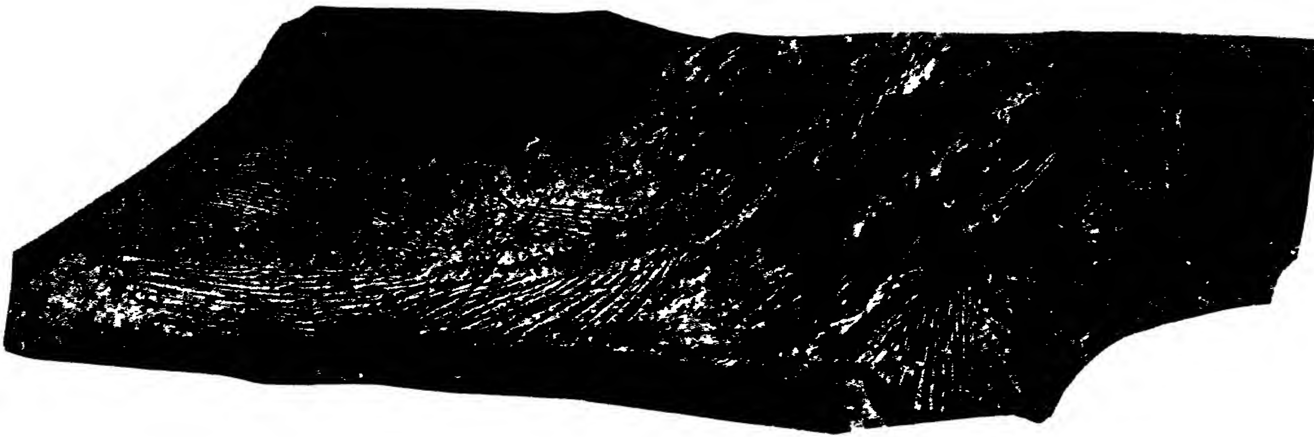
All the photographs were taken when the young one was 6 weeks olds. The photographs have been touched up and only represent size and position.

PLATE I.

A. Baby beside mother.
B & C. Baby on father's back.

PLATE II.

A. Baby alone.
B. Baby in hanging position.



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REPRODUCTION OF COELACANTH FISH

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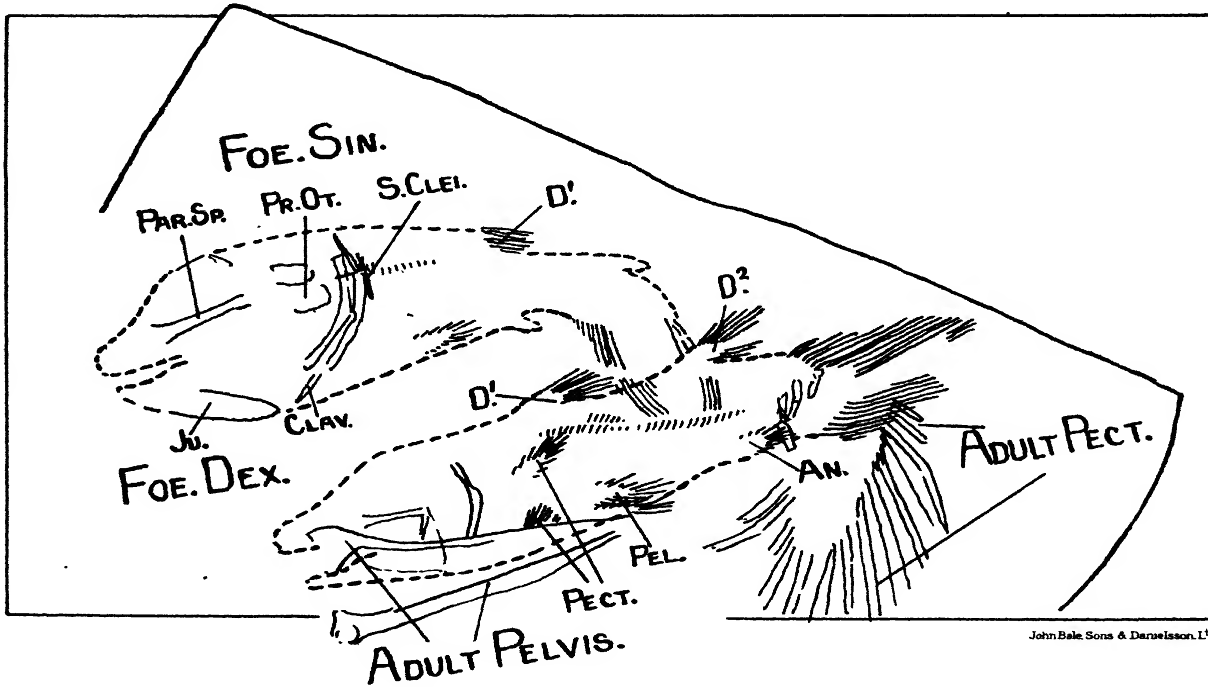

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REPRODUCTION COELACANTH SH

28. The Reproduction of the Cœlacanth Fish, *Undina*. By Professor D. M. S. Watson, F.R.S., F.Z.S.

(Plates I. & II.*)

[Received November 27, 1926: Read March 8, 1927.]

The Cœlacanth fishes have recently gained additional interest from the demonstration (Stensiö, '21, '22, A and B; Watson, '22) that they were correctly associated by Huxley with the Rhipidistia, and indeed represent the only direct descendants of the Osteolepid fishes. They present two phenomena often paralleled by other groups of fishes. As Dr. Stensiö has shown, they exhibit a steady reduction in the extent of the endochondral ossifications in the neural cranium, and they also give us a case, parallel to that of Palæoniscid fishes, of a group which, beginning in fresh water, becomes marine so that its latest members are found in the open oceans. Despite these changes the general structure of their skeleton remains extraordinarily uniform from Upper Devonian to Upper Cretaceous times.

A specimen of *Undina penicillata* Munster, from Solenhofen, which I recently bought in Munich from Herr W. Grimm, adds another curious fact to our knowledge of these fishes. The full-grown fish contains within the body-cavity the skeletons of two individuals of the same species, some 6 cms. in length, which are, I think, the remains of embryos nearly ready to be born.

I have subsequently found that the obverse of this specimen is preserved in the Royal Scottish Museum, Edinburgh. In it the head is preserved and the actual bones are present, but the structure of the embryos is not so clearly shown as in my slab.

The specimen consists almost entirely of a sharp and perfectly preserved mould exhibiting the impression of the squamation of the left side, and of the left side of the axial skeleton. In the region in front of the anal fin the splitting of the slab, whilst leaving the impression of the outer surface of the left side in the dorsal region, has removed quite completely all trace of the basal supports of the dorsal fins and left only faint vestiges of the vertebral column and the ribs. The air-bladder is represented by the smooth impression of its left-hand surface, and one of the two embryos is clearly shown as an impression, retaining in parts traces of actual bone, on this smooth surface. This particular embryo lies with its head directed posteriorly and with its dorsal margin towards that of the adult. The caudal region is turned down ventrally, and the fin rays of the tail overlap onto and are printed through the second embryo. The other embryo lies more ventrally; it also has its head posteriorly and dorsal surface

* For explanation of the Plates see p. 457.

upwards. The pelvic girdle of the adult has twisted round so that the left pelvic fin lies dorsally to the right, and both have been brought into the same plane as the body of the fish.

Despite their very small size the structure of the skeletons of these embryos is very clearly displayed. The head is clearly identical with that of the adult; in the neural cranium the otic capsule is represented by a comparatively large and powerful pair of ossifications, presumably homologous with the bones called prootico-opisthotic by Stensiö. The parasphenoid has exactly the same shape which it possesses in *Macropoma*, and attached to its hinder end are faint traces of a pair of ossifications, no doubt the body of the sphenoid. No details of the bones of the cranial roof can be made out, but the pterygoid was fully ossified and has the normal cœlacanth structure. It is impossible to be sure whether the metapterygoid and quadrate are ossified or not. The opercular apparatus consists of an opercular and a gular on each side identical with those of the adult. The axial skeleton, which is quite well preserved, consists, so far as it is exhibited, of a row of elements, the neural arches, exceedingly closely spaced but of considerable depth, especially in the region below the first dorsal fin. Posteriorly they are lower and even more closely set. In the anterior part of the column, that is the region of the body-cavity, there are a series of subchordal elements, each a short but broad rib. Posteriorly these are no longer seen, and in the caudal region there appear to be no ossified structures at all associated with the vertebral column. The anterior dorsal fin, as in all Cœlacanths, possesses no scaly lobe, and is supported by some eight rays, which lie nearly parallel to one another. No trace whatsoever of its basal element is to be seen, and I think it must have been still unossified. The second dorsal fin possesses a small pointed lobe, the anterior margin of which supports a series of closely-set thin rays, whose length steadily increases until that placed upon the summit of the lobe is of a remarkable length. Of these rays there are approximately ten, and they are much more delicate than those of the first dorsal fin. The posterior margin of the lobe supports about six or eight coarser dermotrichia, which separate from one another more than do those of the anterior border. No trace of the basal support of this fin can be seen. This fin differs from that of the adult in being much more acuminate, but agrees with it, so nearly as can be judged, in the number of its rays. The caudal fin is represented entirely by its dermotrichia, and by the axonosts, which lie between these bones and the neural and hæmal arches. Each axonost is rather feebly ossified and is perfectly straight; the dermotrichia consist of a straight exsert part rounded at its proximal end and flattened distally, where, unlike that of the adult, it shows no evidence of possessing denticles, but is segmented, the individual segments being of nearly the same absolute length as those of the adult. The extreme inner end of each ray is turned inwards towards the middle line in the region where

it becomes attached to the distal end ef the axonost. There appear to be seventeen epichordal fin rays and seventeen ventral rays. The adult possesses eighteen of each. No trace of the accessory caudal fin, the "Pinselflosse," is to be seen, apparently because its elements were not yet ossified. The anal fin has a small lobe, but it is not sufficiently well-preserved to allow the number of its rays to be determined. It appears, however, to be somewhat smaller than the second dorsal, to which it is directly opposed, but is also a pointed fin.

The shoulder-girdle consists of powerful cleithra of the normal Cœlacanth pattern, of small clavicles and supracleithra. No ossification of the primary shoulder-girdle is visible. The pectoral fin arises from a point some distance behind the shoulder-girdle. It has a small, very narrow and pointed lobe surrounded by about sixteen rays. Its shape is not very clearly exhibited. The pelvic fin, whose origin lies a little behind that of the first dorsal, also has a remarkably pointed lobe, and possesses some seventeen rays, of which those of the ventral margin are much longer than those attached to the dorsal edge. The whole fin appears to possess a rounded hinder end. No trace of the pelvic girdle is to be seen.

Only two explanations for the presence of these fish in the body-cavity of the adult are possible. Either they are embryos lying each in an oviduct, or they represent food. It is known from the evidence of *Macropoma* that the Cœlacanths possess a close set spiral valve in the intestine, and the presence of such a structure I think implies that the gut was short and the stomach comparatively capacious. It certainly means that any fish taken in as food would be already completely broken up by the time it left the stomach. If, therefore, the present specimen of *Undina* had been eating its own young, it is reasonable to suppose that if they were taken in at the same time they would, so long as they were recognizable, lie closely pressed together in the stomach, whilst had they been eaten at times sufficiently far apart to come to lie in different portions of the gut, they would differ in preservation, one of them having been more completely digested than the other. In actual practice, such remains of food as are to be seen in the stomachs of fossil fish are always much broken up, and never exhibit their structure with the diagrammatic clearness of the two little fish in the present case. Furthermore, a gut sufficiently long to contain two fish of this size could only be packed into the body-cavity of *Undina*, already largely occupied by the great air-bladder, if it were bent on itself; and we should therefore expect that these fish, if they were food, would not lie in exactly similar positions with respect to the adult. Finally, specimens of *Undina* are so rare that it is improbable that an individual of this genus should succeed in catching in succession, but with an interval of time between them, two exceedingly young individuals of its own species, when the seas in which it was swimming contained many hundreds of

times as many individuals of Leptolepids. Thus it seems in every way probable that these little fish are actually embryos. They agree in all fundamentals with the adult within which they lie. The number of fin rays in each fin is the same within the margin of observational error. The relative proportions and positions of the fins are the same, and there can be no question that the young ones are of the same species as the adult. Their actual position is that which we should expect if each lay in a short straight oviduct. The fact that in the fossil one lies dorsal to the other is explained by that sheering of the ventral part of the fish during its decay and burial which is shown to have occurred by the present position of the pelvic girdle and fins. The appearance of the specimen suggests that the more dorsal embryo lay in the left oviduct, and that the two oviducts were separated from one another by the air-bladder.

Additional evidence that these little fish are indeed still unborn young is afforded by a specimen in the British Museum.

This is a perfectly-preserved Cœlacanth from the Solenhofen slate with a total length of about 6·5 cms., that is, about ·5 cms. longer than the embryos; in the number of its fin rays and in the position of the fins this fish agrees exactly with *Undina penicillata*, the species of Cœlacanth which is most common in the Solenhofen slate and presumably belongs that to that species. This individual differs from the embryos in my specimen in that the neural arches in the caudal region are fully ossified and the hæmal arches show traces of ossification, whereas in my embryo the corresponding elements are still cartilaginous. The Museum fish possesses an ossified basal element of typical Cœlacanth shape to the second dorsal fin, and the pelvic girdle is in part ossified. Thus this fish, although only so slightly larger than the embryos, is in a considerably more advanced stage of ossification, and gives additional evidence that the former are indeed not yet born, although obviously very nearly ready for birth.

The occurrence of vivipary implies an internal fertilization, and leads one to expect a sexual dimorphism in the presence of an intromittent organ in the male, which one would expect to be formed from either the pelvic or anal fins. I have therefore compared the structure of these organs in my female fish with those of all other specimens of *Undina* in the Munich and British Museums, and am unable to find any definite differences between their conditions in the various specimens. The number of specimens in which these fins are well shown is, however, very small, but it is at least clear that marked sexual differences in them do not occur.

Vivipary is a phenomenon that has arisen repeatedly amongst fish; it is exhibited by many groups of Elasmobranchs and by Teleosts of many different families. The conditions under which it has arisen appear never to have been analysed, and it it difficult in the present state of our knowledge to say to what extent it is to be associated with large yolky eggs, or how far is

may arise amongst fish with small eggs. In Teleosts nutrition of the growing fœtus appears to be carried out by the production of a special secretion from the wall of the oviduct, which is either absorbed by the yolk-sac or is actually eaten by the little fish. The latter mode is that which is adopted by those Urodeles which are viviparous, and appears to be that which is most likely to have occurred in the case of *Undina.*

The specimen just described affords, I believe, the only evidence of vivipary in any fossil fish, and adds a feature of interest, though of very uncertain significance, to our knowledge of the Cœlacanths.

EXPLANATION OF THE PLATES.

Plate I.

Photograph of a slab of lithographic stone from Solenhofen containing the impression of a skeleton of *Undina,* lacking the head but containing two embryos.

Plate II.*

Untouched photograph of a part of the specimens shown in Pl. I.

Key-figure. Pl. II.

Outline drawing of part of the specimen of *Undina,* to serve as a key to the photograph (Pl. II.). × 2 approx.

An., anal fin; *Clav.*, clavicle; *D.*[1], first dorsal fin; *D.*[2], second dorsal fin; *Fœ.Dex.*, fœtus in the right oviduct; *Fœ.Sin.*, fœtus in the left oviduct; *Ju.*, gular plate; *Par.Sp.*, parasphenoid; *Pect.*, pectoral fin; *Pel.*, pelvic fin; *Pr.Ot.*, pro-otic.

* See figure facing Pl. II. for a key to the photograph.

29. The Visceral Lymphatic Channels of the *Catarrhinæ*. (Illustrated by the direction of the spread of Tuberculosis.) By J. BEATTIE, M.D., M.Sc., C.M.Z.S., Anatomist to the Society, and Demonstrator of Anatomy, University College, London.

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CONTENTS.

[This paper forms part of a study of tuberculosis in Primates conducted by Dr. H. H. Scott and the Author at the Prosectorium.]

Introduction.

During the year 1926 and the first three months of 1927, forty mammals died in the Collection of the Zoological Society as the result of tuberculosis. Of these thirty-seven were Primates and, except for ten, all were Catarrhine monkeys. These particular monkeys appear to be very susceptible to tuberculosis and show, in the later stages of the disease, very widespread lesions. A detailed study of these animals showed that the disease spreads in no haphazard manner, and that certain well-defined routes were followed. These routes, in the early stages of the disease, correspond closely to the courses of lymphatic vessels. This conclusion, which was suspected after a few cases had been seen, was not proved definitely until a number of normal animals had been dissected and the lymphatic channels of these injected. The agreement between the findings on the normal animals and the dissemination of the lesions in the diseased subjects showed that the morbid anatomy of early Primate tuberculosis depends almost entirely on the topography of the visceral lymphatic system.

It has been assumed too readily by many observers that the lymphatic system of all the Primates is identical with the arrangement found in Man. There is little doubt that the connections of the various lymphatic nodes with the thoracic and abdominal viscera follow a common plan, but the details of these connections have not been expressed in definite terms. Various

American observers have investigated the problem of the development of lymphatic vessels, and have shown that in the Primates there is considerable variation in the connections of the terminal vessels with the venous channels. It has been pointed out that the New World Monkeys have well-marked lymphatic connections with the renal vein and inferior vena cava. These post-caval connections are absent in the Old World Monkeys and the Anthropoid Apes—and, of course, in Man. It is not the terminal channels that are important in the spread of tuberculosis, but rather the channels which drain the viscera into the lymphatic glands and the connections of the efferents of these glands with other nodes and with the terminal vessels. When the disease has reached the stage when infective material is being thrown into the terminal lymphatic vessels the spread of the disease ceases to depend on lymphatic connections. The literature on the topography of the Primate lymphatic nodes is scanty and in many ways inaccurate. The details of the drainage-areas of the groups of glands are wanting. It is to remedy this and to provide a secure basis for the morbid anatomy of Primate tuberculosis that this work was undertaken.

Material.

This work is based primarily on the lymphatic system of two specimens of *Macacus rhesus* and two specimens of *Cercopithecus sabeus*. These four animals were normal, in so far as they had not suffered from any infective disease, but had been chloroformed owing to injuries which they had received from their companions. The twenty-seven Old World monkeys which died of tuberculosis, as mentioned above, were studied, and they provided useful information on the question of the reversibility of the lymph-flow as well as on the drainage-areas of glands.

The injection-mass used for the injection of the lymph-vessels consisted of

Oil colour Prussian Blue, 2 parts.
,, Methylated Ether, 5 parts.
,, Turpentine, 15 parts.

This was prepared and used in the manner described by Jamieson and Dobson in the 'Journal of Anatomy,' vol. xlv. p. 7. As in the human subject it was found that the best injections were obtained in young animals. As it has been recommended that injection should take place before *rigor mortis* sets in, or when this condition vanishes before the advance of decomposition, all the animals were kept at room-temperature for four days before they were injected. No attempt was made to inject before the onset of *rigor mortis*.

In describing the visceral lymphatics each organ is treated separately, followed by a description of the lymphatic connections of the thoracic and abdominal walls. Where there is a wide divergence in the lymphatic arrangements in animals investigated the differences will be described.

The Lymphatic Vessels and Glands of the Thorax.

Lung.

Injection under the serous covering of the lung demonstrates that there is a subpleural plexus of lymphatic vessels which is drained in the direction of the hilum. This plexus connects with a deeper plexus, which extends into the parenchyma along the bronchi. The two plexuses, although interconnected, do not appear to communicate extensively in normal conditions. When obstruction of the deeper plexus takes place by the caseation and destruction of the lymph-glands into which it drains, the connections open up and the vessels of the superficial plexus drain the whole of the lymph from the lobe. The lobar lymphatic vessels from the deep plexus drain into a gland lying in relation to the main bronchus. The superficial plexus drains into a gland at the hilum of the lobe. Within the lung parenchyma masses of lymphoid tissue can be seen in sections of normal lungs. These masses are found around the larger branches of the vessels and the bronchus to the lobe. They are not found close up to the cortical parts of the lung. It is probable that these masses of lymphoid tissue are the seats of the primary foci of tuberculosis. In animals examined which showed early infection by tubercle bacilli the primary focus was found in the region where these masses are more frequently found. It is not likely that the primary lesion is due to inflammatory changes within the alveoli. Shattock showed that tubercle bacilli can pass through an intact mucous surface, and that the alveolar epithelium can be penetrated readily is evident from the number of carbon granules which are to be seen within the lung-parenchyma and the glands draining the lung-substance.

The glands draining the lungs are arranged in the following groups:—

(*a*) Intra-pulmonary or lobar.
(*b*) Broncho-pulmonary.
(*c*) Tracheo-bronchial.
(*d*) Para-tracheal.

The intra-pulmonary glands consist of small nodes of lymphathic tissue lying close to the large bronchi, indefinite mass of tissue in relation to the blood vessels and scattered lymphoid cells in the more peripheral parts of the lung. The broncho-pulmonary glands are small nodes which lie close to the hilum of the lobe which each drains. There is, as a rule, a definite node for each lobe. These small nodes drain the lymph from the superficial plexus of the lung. The efferents from these nodes pass along the bronchi to reach the para-tracheal glands. Sometimes they may be interrupted at the tracheo-bronchial glands. The tracheo-bronchial glands are arranged in two groups, a superior and an inferior. The superior group consists in most small monkeys of a single mass of lymphatic tissue. It lies on the upper aspect of the main bronchus and invariably drains the upper lobe of the

lung. The inferior group consists of another single node, but this is usually very much larger than the superior gland. The group lies inferior or caudal to the bronchus and in the inter-bronchial space below the bifurcation of the trachea. The para-tracheal glands are to be found along the lateral aspect of the inferior half of the trachea. They are small nodes usually consisting of a pair for each side.

Heart.

No experiments were carried out to show the lymphatic connections of the heart. Tuberculosis of the heart is very rare. It is usually due to an embolus entering the coronary arteries and becoming impacted in one of the terminal branches. The lesions are always to be found over the ventricles and are superficial. On the posterior surface of the pericardium a few glands are to be seen which, from their position, correspond to the posterior mediastinal glands of human anatomy. Sometimes these become involved in the caseation process which takes place in the posterior mediastinum in the glands between the bronchi. When this occurs there is usually considerable excess of pericardial fluid within the pericardial sac.

Thymus.

Deep to this gland a group of glands are to be seen lying in the areolar tissue on the superficial aspect of the pericardium close to the roots of the great vessels. They drain this organ and send efferents backwards to connect with those from the glands of the posterior mediastinum and the efferents from the bronchial glands to form the broncho-mediastinal lymph-trunk.

Pleura.

Beneath the serous coat of the pleura there lies in the sub-pleural tissue a plexus of lymphatic vessels which is continuous over the whole of the parietal pleura. Drainage from this plexus takes place into four groups of glands. The diaphragmatic pleura is drained in some animals in three zones—anterior, middle, and posterior. Owing to the very free anastomosis between the vessels it is impossible to decide the boundaries, if any, of these zones. It is probable that the central tendon is drained by the vessels of the central zone and that the anterior and posterior regions are drained into separate groups of glands. These glands when present are very small and can only be detected with difficulty. The anterior zone is drained into a small node or nodes lying near the termination of the internal mammary artery. The efferents from the group are conducted into the lowest of the sternal glands. The middle group of glands, when present, is situated near the inferior vena cava where it emerges from the diaphragm. When this group is absent drainage takes place into the posterior mediastinal glands. The posterior group is always small in numbers, never more than two nodes on each side.

The efferents pass into the posterior vertebral glands. The posterior glands usually lie on the crural fibres. When absent the vessels drain into the posterior vertebral vessels directly.

The costal pleura is drained by two sets of vessels—anterior and posterior. The anterior set ends in glands which are situated along the course of the internal mammary artery—these are the sternal glands. The sternal glands drain the anterior thoracic wall and the muscles covering it. The lateral thoracic wall as far back as the mid-axillary line is drained into the same group. The sternal glands vary in number from one to seven. One large gland is always seen lying behind the medial end of the clavicle. The vessels from the seventh to the tenth spaces join to form a common trunk which empties into the lowest of the sternal glands. The lymphatic vessels of the lateral thoracic wall communicate freely with the vessels draining into the axillary region. It is frequent to find in animals which have extensive infection of the pleura that the axillary glands are inflamed and even caseous.

The posterior thoracic wall and the posterior part of the lateral thoracic wall are drained into glands which lie along the vertebral column on the lateral aspect of the vertebral bodies. These glands may number eleven, but it is more usual to find that the number is reduced to two or three. The vessels of the lower five or six spaces are drained into a descending trunk, which is made up of efferents from the lowest glands of the vertebral group. The descending trunk on the right side passes downwards through the diaphragmatic opening which transmits the aorta and usually ends in one of the paraortic glands which lie on the crus of the diaphragm in this region. From these efferents pass out to the cisterna chyli or to the thoracic duct. On the left side a similar arrangement is to be found. The vessels from the upper six spaces drain into the vertebral glands, from which efferents emerge. The efferents on the right side join to form a longitudinal trunk, which empties into the subclavian lymph-trunk or opens separately into the junction of the internal jugular vein with the subclavian vein. On the left side it is not so common to find a single ascending trunk, but the efferent vessels are usually drained into the thoracic duct itself in the upper thoracic part of its course. From this it would appear that the thoracic duct on the left upper part of its course is homologous with the ascending channel on the right side.

The mediastinal pleura is drained into the anterior and posterior mediastinal lymph-glands.

To summarise the drainage of the thoracic wall, it will be seen from the above description that the lateral thoracic wall is drained into longitudinal channels into the thoracic duct and its homologues. The lower thoracic region is connected with the abdominal lymphatics. This fact explains why it is so common to find enlarged glands in the region of the cœliac axis.

The subpleural lymphatic plexus of the diaphragm communicates with the lymphatics of the abdominal cavity by fine channels

which pass between the muscle and tendinous fibres. These communications link up the subphrenic surface with the pleural surface. In addition to these fine channels extensive communications also take place in the interval between the sternal and costal parts of the diaphragm. These vessels run alongside the superior epigastic artery and find their way into the falciform ligament of the liver and the convex surface of that organ. This communication is exceedingly important, as it is frequent to find in the falciform ligament and on the convex surface of the liver very fine milia, when the sternal glands are caseous and the flow of lymph in an upward direction is impeded. There was no sign of blood vascular spread in these cases, as no other organ had been affected and the glands at the hilum of the liver were normal.

As no valves were found in the injection specimens along the course of any of the afferent vessels carrying lymph from the thoracic wall into the lymph-glands, there is no mechanical reason why a retrograde flow of lymph should not take place into the abdominal lymphatics or into the axillary glands. In the efferent vessels from the lungs there are no valves in the broncho-mediastinal trunk until the termination of this channel either by its emptying into the venous system or by joining with any of the other great trunks.

Lymphatic stasis within the lung does not seem to occur very frequently. This is to be explained by the frequency of adhesions to the parietal pleura through which the lobar lymph is drained to the parietal pleural vessels. Involvement of more than one lobe is frequently explained by the inhalation of infective material from one lobe to another and, second, by the formation of interlobar adhesions.

There appear to be in the thoracic cavity some glands which may be called key-glands. These masses of lymphoid tissue are situated in the following places:—

(*a*) The uppermost sternal gland through which all the lymph from the anterior thoracic wall passes. When this gland is found to be caseous it is certain that the disease has spread into the blood-system and the whole of the body becomes riddled with milia.

(*b*) The uppermost vertebral gland lying in the posterior mediastinum on the neck of the first or second rib. Caseation of this gland and blood-infection are always found together.

(*c*) Large glands situated in the inter-tracheal space. They are the key-glands of the lungs and are on the last line of lymphatic resistance to the spread of the disease from these organs to the blood.

(*d*) Two glands lying on either side of the cisterna chyli and found caseous when the lower lobes of the lungs are tubercular.

When any of these give way the disease becomes at once a generalised septicæmia.

The infective material poured into the blood-stream appears to be of two kinds:—

(*a*) Bacterial—that is, actual bacilli. These give rise to fine milia in organs all over the body.

(*b*) Embolic. Whereas the bacilli usually gain entrance *via* the lymphatic channels, the embolic material is usually poured into the pulmonary veins when a tubular focus ruptures into a pulmonary vein.

The Lymphatic Vessels and Glands of the Abdomen.

Stomach.

The stomach is drained in exactly the same manner as the stomach in Man. Two lines of glands are seen—one along the great curvature and one along the lesser curvature. Drainage takes place in the region of the body of the stomach in the direction of the hilum of the spleen. These vessels correspond with the vasa brevia, which reach the stomach from the splenic artery. The vessels of the greater curvature drain to the right into a gland which is situated dorsal to the first part of the duodenum and in close contact with the upper part of the body of the pancreas. The vessels of the cardia are drained posterior to the œsophagus, and enter a gland which is situated near the point where the œsophagus enters the abdomen. The vessels of the lesser curvature drain to the right into the gland which drains the whole of the great curvature. The left part of the lesser curvature drains upwards into the region of the œsophagus and usually terminates in the gland which drains the cardia. This gland is also the termination of the vessels of the lower part of the œsophagus. The last few glands on the right part of the lesser curvature are in close relation to the glands at the hilum of the liver. It is probable that these glands drain into the superior pancreatic gland described above. The vessels from the inferior œsophageal gland or glands (there may be two nodes in this region) follow the course of the left coronary artery and end in a group of glands in the region of the cœliac axis. The vessels from the right part of the lesser curvature and greater curvature after passing through the superior pancreatic gland pass along the course of the right gastro-epiploic and hepatic arteries to reach the cœliac group of glands. This group drains the liver and the main part of the pancreas. There is no gland in the region of the gall-bladder. The vessels from this organ reach the cœliac glands after passing through the glands at the hilum of the liver. These latter glands are usually three in number, and are never large unless there is some inflammatory focus in the liver.

It has been mentioned above that there is some communication with the lymphatic vessels of the spleen by way of small channels running with the vasa brevia. At the hilum of the spleen a

gland could be detected, and it is probable that the gastric lymphatic vessels join up with some from the spleen and enter the glands at the cœliac axis. It may be mentioned here that it is frequent to find the spleen displaying tubercular lesions of considerable magnitude when no other abdominal viscus, not even the kidney, is affected. Whether tubercular material may gain entrance to the spleen by these short vessels from the stomach, which has been charged by the swallowing of tubercular sputum, remains obscure. One cannot find any adequate anatomical grounds for explaining this phenomenon. It may be that tubercular material passing down in the posterior descending lymph-channel from the lower thoracic interspaces may infect the spleen. This does not meet the case, as it is just as common to find splenic tuberculosis in left-sided lung-infections as right-sided ones. The supposition of Sampson Handley that cancer-particles may enter the abdominal cavity by way of the lymph-vessels, which pass down with the superior epigastric artery into the abdomen and infect the liver and other organs, is based on known anatomical facts, but beyond the infection of the convex surface of the liver and the great omentum it is hard to see how other parts of the abdomen become infected. That the great omentum may be drained into vessels which pass near the spleen is possible, but in injected specimens it is difficult to decide whether these vessels normally drain in this direction. It is more frequent to find the vessels passing upwards to the greater curvature of the stomach and then into the glands near the pylorus. The early infection of the spleen in pulmonary tuberculosis remains unexplained.

Liver.—The lymphatic paths correspond in their arrangement with the condition found in Man. The efferents from the glands at the hilum drain into the cœliac glands without any interruption.

Pancreas.—Along the superior border of the pancreas a few small nodes are found almost embedded in the substance of the gland. The glands at the tail drain to the left into the lieno-renal ligament and reach the cœliac glands. The glands on the right side at the head and body are drained into a single large gland lying on the dorsal surface of the pancreas near its upper border. From this point efferents pass into the cœliac glands. A small node may be seen, but is not constant in appearance, at the most inferior part of the pancreas. This gland drains the inferior edge and the greater part of the duodenum. It is connected with the superior pancreatic gland and also by channels with the superior mesenteric lymph-glands.

Intestine.—The lymphoid tissue of the intestine lies in the mucous and submucous coat. The distribution of it closely approximates to that in Man. The cæcum and cæcal appendix, which is not differentiated off from the cæcum, have large masses of lymphoid tissue in the submucous and mucous coats. The

tissue is distributed in the following manner in the small intestine:—

(*a*) Intra-intestinal—*i. e.*, lymphoid tissue which is embedded in the wall of the intestine.

(*b*) Mesenteric. Small nodes lying close to the mesenteric attachment to the gut-tube, and larger nodes near the root of the mesentery.

(*c*) Superior mesenteric group.

The mesenteric glands lying in the mesentery at the edge of the gut are the first glands to be affected in tuberculous disease of the gut. The larger masses are always swollen and pink when the smaller nodes are affected. They do not caseate until relatively late. The glands at the origin of the superior mesenteric artery are grouped closely round the main stem of the vessel and round the aorta. It is hard to separate them from the cœliac glands which lie on the aorta immediately above them. They are closely connected with these latter glands and numerous efferents from the superior mesenteric glands pass to them.

The arrangement of the lymph-nodes differs in the large intestine slightly from that in the small. The intra-intestinal tissue is, of course, very much greater. The glands at the mesen teric border do not lie up close to the gut, but about a centimetre or so distant. These glands are constant in that they lie in relation to the arterial arcade which is to be found near the mesenteric border of the gut. The glands in the mesentery are arranged in large masses around the principal branches of the superior and inferior mesenteric arteries to the large gut. In the ileo-cæcal region the glands in the mesentery may number as many as twelve, arranged in two parallel rows, one on each side of the artery. The appendicular region and the cæcum are drained into the medial of these rows and the ascending colon into the more lateral one. Injection shows that it is probable that all the lymph from this region is filtered as many as two or three times before the glands around the main arteries are reached. In the region of the rectum the glands are in close relation to the posterior rectal wall, where they form two rows lying on each side of the superior hæmorrhoidal artery. The efferents from the mesenteric glands of the large intestine drain into the gland-groups around the origin of the main vessels. From the way the injection-mass passes into the deeper glands it appears that each gland at the root of the main vessel drains a definite area. When the injection is forced in under too high a pressure the connecting paths with the other glands open up and obscure the picture. The efferents from the glands around the roots of the large vessels pass upwards into the cisterna chyli. The drainage of the gut and its associated glands—liver, pancreas, and spleen—is independent of the drainage of the walls of the abdominal cavity in exactly the same way as the thoracic viscera are drained by independent channels from the parietes of that cavity.

Pelvic Organs.

Bladder.—The lymph-vessels of the bladder were not investigated by injection-methods. No cases were discovered where infection of this organ had taken place.

Kidneys.—The kidney becomes affected in tuberculosis from the blood-stream. In the arrangement of its vessels the kidney is drained into the lumbar lymph-glands situated lateral to the aorta and on the right side posterior to the inferior vena cava. The efferents pass into glands which are constant in their appearance and lie at the level of the renal arteries. These glands are associated closely with the vessels from the gonads. The efferents from the glands draining the kidney pass into the cisterna.

Prostate.—The vessels of this organ were not well injected. It is extremely difficult to obtain a good injection, owing to the extensive venous plexus around the base of the bladder and the capsule of the gland. When the cannula is inserted within the capsule the injection-mass will not run easily and a complete picture is hard to obtain. Fine vessels are to be found surrounding the vas deferens. They drain into the external iliac glands. The other vessels pass some laterally into the hypogastric glands and others posteriorly into the lateral sacral glands. There is a connection with the vessels draining the membranous urethra.

The other abdominal organs were not investigated, as it is hoped to communicate later a complete account of the vascular and lymphatic supply of the genital region.

Abdominal Wall.

The vessels draining the parietes of the abdominal cavity converge on glands which, like those of the thorax, are independent of the visceral glands. The parietal glands are arranged in the following groups:—

(*a*) Lumbar. These lie on either side of the aorta. They vary greatly in size. The largest gland is situated at the level of the fifth lumbar vertebra and the others are much smaller, being no larger than the size of a small pea, whereas the large lumbar gland may be as large as a bean. There are five or six glands on each side.

(*b*) Common Iliac. A group of five or six small nodes, which surround the common iliac artery.

(*c*) External Iliac. Small glands varying in size from little larger than a pin-head to the size of a pea. They surround the external iliac artery.

(*d*) Hypogastric. This group of glands varies considerably in number, but at least three or four are present. A few lie on the main trunk of the internal iliac artery, but the greater number are found on the branches of the vessel.

(*e*) Sacral. These glands are not constant in appearance. They are to be found along the line of the anterior foramina. Two or three on each side appears to be the greatest number present.

External Iliac Glands.

The external iliac glands drain the lymph from the lower limb *via* the inguinal glands, from the anterior abdominal wall below the umbilicus and from the external genitalia. In addition to the lymph from these regions, the lymph from the vagina, cervix uteri, fundus of the bladder, and the membranous urethra drains into the group. The glands are arranged into two sets—medial and lateral. The lateral group lies lateral to the artery and appears to drain lymph entirely from the inguinal glands. The medial group forms the primary centre for the pelvic organs mentioned above.

The efferents from the external iliac glands pass upwards into the common iliac group, which lie just above the first group. It is difficult to separate the two groups in some animals. They drain the lymph from the external iliac and the internal iliac or hypogastric groups.

From the pelvic walls and from the prostate and the urethra vessels pass alongside the main branches of the hypogastric artery and enter the glands forming the internal iliac groups.

The efferents from the common and internal iliac groups pass into the lowest lumbar gland. From this gland a large trunk arises, which is called the ascending lumbar trunk. It passes upwards lying lateral to the aorta and enters the cisterna chyli. The two lumbar trunks receive efferents from the other lateral lumbar glands. The lumbar glands, in addition to draining efferents from the regions mentioned above, also drain the posterior abdominal wall. The vessels draining this region accompany the lumbar vessels in the same way as the intercostal lymph-channels in the thorax.

The Thoracic Duct.

This important structure arises from the cisterna chyli about the level of the first lumbar vertebra, and passes upwards to terminate at the junction of the internal jugular and subclavian veins on the left side. In none of the specimens dissected and injected was the thoracic duct absent. The cisterna obtains the lymph from all the alimentary canal either by way of a single intestinal trunk or by several large efferents which pass into its anterior surface. On each side the ascending lumbar trunks enter and near its upper end the descending thoracic trunks terminate. When the descending thoracic trunks are not present the lymph from the lower six interspaces passes directly from the posterior intercostal glands into the thoracic duct. In every case, however, the ascending thoracic duct was formed on the

right side, but only in one specimen was the right lymphatic duct a recognisable structure. The thoracic duct receives before it passes into the right innominate vein the subclavian trunk or trunks and also the internal jugular trunk. On the right side the subclavian trunk and the right ascending thoracic trunks join to form a common vessel. The thoracic duct receives also the left broncho-mediastinal trunk. This vessel drains the left posterior mediastinal glands and the left half of the great mass of glands at the bifurcation of the trachea. On the right side the broncho-mediastinal trunk enters the right innominate vein or the lowest part of the internal jugular vein. It is not usual to find the trunk joining with the subclavian lymph-trunk.

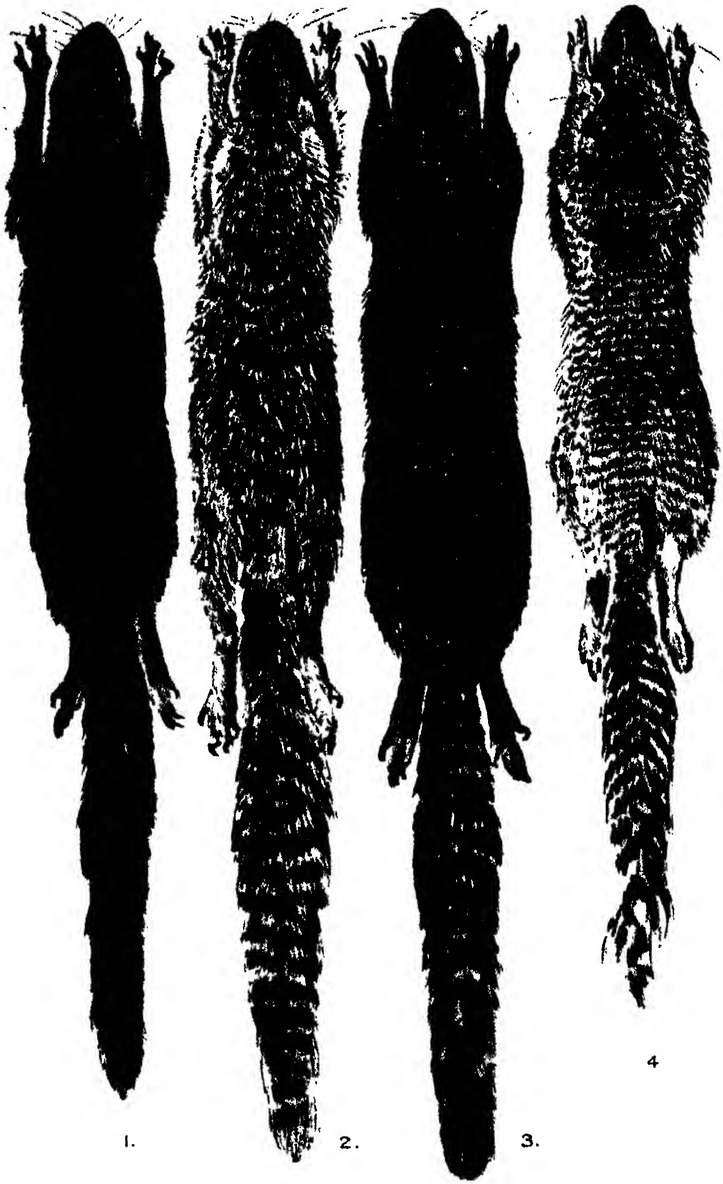
Conclusions.

(1) The arrangement of the visceral lymphatic system of the Catarrhine monkeys examined shows that there is little difference between the condition found there and the usual condition present in Man.

(2) The connections of the various glands and the drainage-areas of these structures as determined by injection-methods throw considerable light on the spread of tuberculosis in the Primates examined.

(3) Tuberculosis gains entrance to the lymphatic system almost immediately after the bacilli enter either the air-passages or the intestinal tract.

(4) The distribution of the lesions of the disease depends entirely during the early stages on the topographical anatomy of the lymphatic system.



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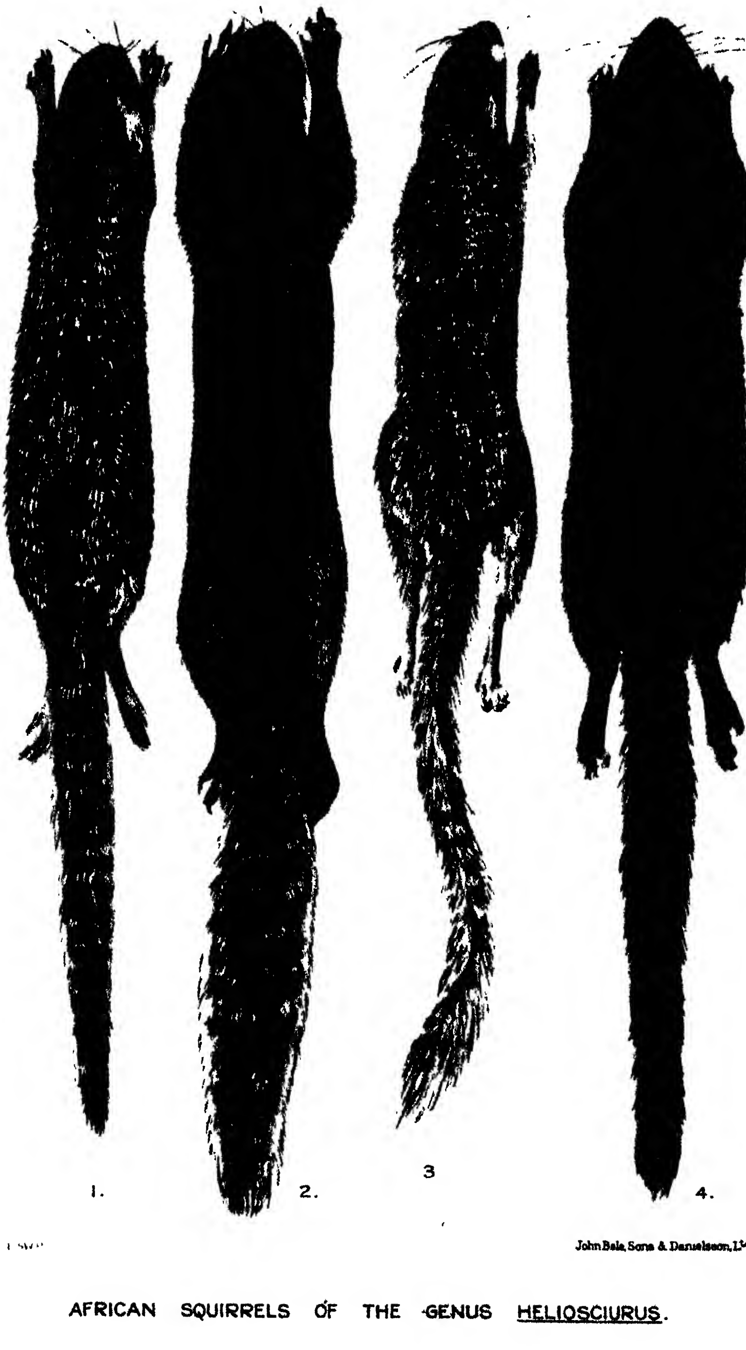

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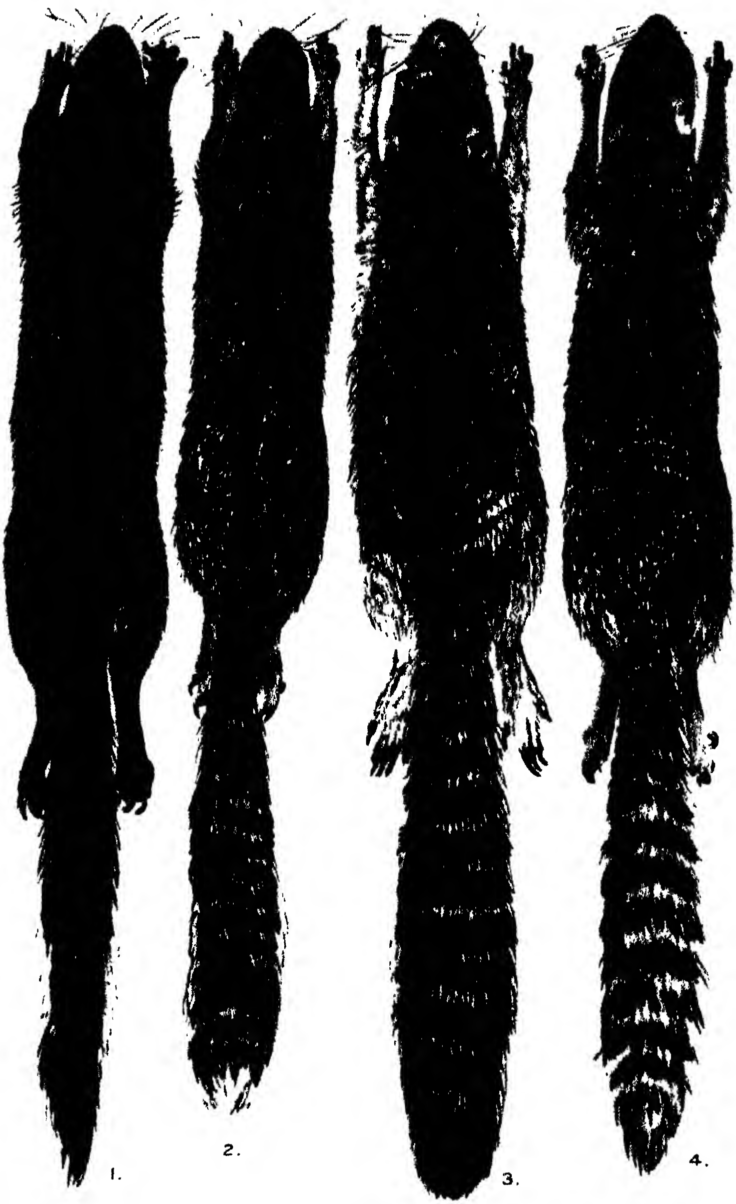

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AFRICAN SQUIRRELS OF THE GENUS HELIOSCIURUS.

30. Some Notes on the African Squirrels of the Genus *Heliosciurus*. By Major C. M. Ingoldby, R.A.M.C., F.L.S., F.Z.S.

[Read February 22, 1927.]

(Plates I–IV.*)

By courtesy of the authorities I was recently able to lay out the entire material of this genus in the British Museum collection. This includes examples of almost all described forms (some 45 subspecies included in a number of species variously estimated as from 8 to 11) and consists of several hundreds of specimens. Consideration of this material appears to lead to certain conclusions which are presented below. I have to acknowledge my deep indebtedness to Mr. Martin A. C. Hinton and to Mr. Oldfield Thomas for their very friendly encouragement and interest and their help in allowing me access to literature and for valuable gifts of "Separates." I am also indebted to Mr. R. Oldfield for most kind and patient assistance.

The present paper deals only with those forms included in *Heliosciurus* in Thomas's sense: *i. e.* medium-sized soft furred Tree-Squirrels of Equatorial Africa, normally possessing four teeth only in the upper cheek-tooth series. Hollister has shown reasons for including *Æthosciurus* in this genus. It may perhaps be considered that the following conclusions support that view. Briefly these are as follows:—

(1) That the squirrels of the genus *Heliosciurus*, as at present understood, all belong to one species only. Widely as they differ from one another in external appearance, the many forms are merely climatic phases of one squirrel.

(2) That the squirrel is a highly labile and responsive animal showing little ascertainable tendency to fixity of form.

(3) That too great regard has been paid to apparent geographical isolation in the erection of new species and subspecies, all of which appear to depend on variation in size and colour only, without regard to the essential facts of geography and their relation to adaptive changes, with the result that in many instances the same form has been described under several different names in various parts of its area of distribution, merely because the patches inhabited may not be contiguous. This has caused confusion, and has markedly tended to obscure the true relationship of members of the group.

A convenient starting-point for any work on these squirrels is, of course, Oldfield Thomas's paper of 1909 (Ann. Mag. N. H. [8] iii. p. 467), in which *Heliosciurus* was first awarded full generic rank. Certain changes have since then been made,

* For explanation of the Plates see p. 487.

chiefly by Thomas, in the list of species and subspecies allowed by him in that paper, and the following list of forms gives the classification as at present accepted.

		Type-locality.
1.	*H. gambianus*, Og. 1835.	Gambia.
2.	„ *senescens* Thos., 1909.	Senegal.
3.	„ *limbatus* Schwarz, 1916.	Bosum, Ukam River, E. Neu-Kamerun.
4.	*H. bongensis* Heugl. 1877.	Bahr el Ghazal.
5.	„ *canaster* Thos. & Hinton, 1923.	Jebel Marra, Darfur.
6.	*H. multicolor* Rüpp. 1835–40.	L. Tsana, Abyssinia.
7.	„ *lateris* Thos. 1909.	Lado.
8.	„ *elegans* Thos. 1909.	Mt. Elgon.
9.	„ *cænosus* Thos. 1909.	R. Ubanghi, 19° 30′ E.
10.	„ *omensis* Thos. 1909.	Kum Dingani, N.E. of L. Rudolph, Lower Omo.
11.	„ *madogæ* Hell. 1911.	Uma, 50 miles N. of Mimule, Uganda.
12.	„ *kaffensis* Neum. 1902.	Anderacha, Kaffa (in silvis ad 2600 m.).
13.	„ *abassensis* Neum. 1902.	L. Abassa, Abyssinia.
14.	*H. rhodesiæ* Wroughton, 1906.	W. of N'dola, N. Rhodesia.
15.	„ *loandicus* Thos. 1923.	N'dalla Tando, Loando, N. Angola.
16.	*H. mutabilis* Pet. 1892.	Boror, 17° S.
17.	„ *beiræ* Roberts, 1913.	Beira.
18.	„ *shirensis* Gray, 1867.	Shiré River.
19.	„ *chirindensis* Roberts, 1913.	Chirinda Forest.
20.	*H. undulatus* True. 1892.	Mt. Kilimanjaro.
21.	„ *daucinus* Thos. 1909.	Mombasa.
22.	„ *dolosus* Thos. 1909.	Mafia Island, Tanganyika Territory
23.	„ *marwitzi* Müller, 1911.	Mt. Kilimanjaro.
24.	„ *shindi* Hell. 1914.	Summit of Mt. Umengo, Taita Hills.
25.	*H. punctatus* Temm. 1853.	Secondi and Bibiani, Gold Coast.
26.	„ *savannius* Thos. 1923.	Béoumi, 250 miles N. of Grand Bassam, Ivory Coast.
27.	*H. keniæ* Neum. 1902.	W. side of Mount Kenya (at an altitude of 8000 feet).
28.	*H. rufobrachium* Watr. 1842.	Uplands of Fernando Po.
29.	„ *pasha* Schwann, 1904.	Bellima, Monbuttu.
30.	„ *aubryi* M.-Edw. 1867.	Gabun.
31.	„ *benga* Cabr. 1917.	Cabo San Juan, Spanish Guinea.
32.	„ *isabellinus* Gray, 1867.	Not known; but probably from the Lower Niger.
33.	„ *leonensis* Thos. 1923.	Mano, Sierra Leone.
34.	„ *emissus* Thos. 1923.	Kumbo (6° 50′ N., 10° 50′ E.), S.E. Nigeria.
35.	„ *acticola* Thos. 1923.	Santa Isabel, Fernando Po.
36.	„ *caurinus* Thos. 1923.	Gunnal, Portuguese Guinea.
37.	„ *hardyi* Thos. 1923.	Béoumi, 250 miles N. of Grand Bassam, Ivory Coast.

		Type-locality.
38. *H. rufobrachium obfuscatus* Thos. 1923.		Ekkonnanakku, Oban district, S.E. Nigeria.
39.	„ *maculatus* Temm. 1853.	Gold Coast.
40.	„ *nyansæ* Neum. 1902.	Kwa Kitoto, Kavirondo; Mt. Elgon.
41.	„ *semlikii* Thos. 1907.	Beni, Semliki River.
42.	„ *medjianus* Allen, 1922.	Medje, Belgian Congo.
43.	„ *rubricatus* Allen, 1922.	Avakubi, Belgian Congo.
44.	„ *arrhenii* Lönnb. 1917.	Masisi, 3 days W. of Lake Kivu.
45.	„ *lualabæ* Thos. 1923.	Lodja, Upper Lukenge River, S. Congo.

[Of these forms all but three, namely *H. g. limbatus*, *H. u. shindi*, and *H. r. arrhenii*, are represented in the British Museum.]

Thomas (Ann. Mag. N. H. [8] iv. 1909, p. 101) grouped the Savannah forms into one "*gambianus* group." Schwarz goes further, reverts in fact to the view expressed by Jentink, who regarded all members of this group as one species. I do not find recognition anywhere of the extremely close relationship of *H. mutabilis* with its various subspecies to *H. rhodesiæ* Wroughton or to *H. undulatus* True. There remain *H. punctatus* and its allies and the large and ever-growing group of which the type is *H. rufobrachium* Waterh.

It may be pointed out at the outset that, while there have been a large number of new subspecies recently described in this genus, the tendency has been to "sink" species. Of the eleven species allowed by Thomas in 1909 three (*kaffensis*, *abassensis*, and *isabellinus*) have since come to be regarded by him as subspecies only.

At the risk of tedious repetition, I propose describing the steps by which I was led in the first place to attempt a revision of the genus.

Having arranged the material roughly in accordance with its geographical distribution the following facts became apparent:—

1. That the northern small pale forms (*H. g. senescens*, *H. g. gambianus*, *H. bongensis*, *H. b. canaster*, *H. m. lateris*, *H. m. elegans*, and *H. m. madogæ*) form a continuous series roughly along latitude 10° N. from Senegal to Abyssinia, where they meet and grade with *H. m. multicolor*.

2. That along latitude 10° S. corresponding and in some cases apparently identical forms (small specimens of *H. rhodesiæ* and *H. r. loandicus*) occupy the woodland grass country.

3. That in the contiguous area of secondary and gallery forest the Savannah forms mentioned above were represented in continuous series by forms of similar or very slightly larger size but of darker coloration: such are *H. punctatus*, *H. r. emissus*, and (getting slightly larger still, but otherwise matching well) various other subspecies of *H. rufobrachium* and *H. multicolor* (*caurinus*, *isabellinus*, *acticola*, *cænosus*, *abassensis*, and *omensis*).

4. That the two series of forest and Savannah forms run into each other, so that between say *H. g. gambianus* of the Northern territories of the Gold Coast and *H. punctatus* of the north of the forest region of Ashanti and the gallery forest of the Black Volta region, a complete set of intermediate forms occurs.

Now in the forests of the Gold Coast Colony another well-known squirrel of this genus is found which differs very strikingly from *H. punctatus*. This is a large squirrel of saturate colour, dark almost black on the back, with brilliant suffusion of reddish-orange over the belly, brighter and redder on the limbs: *H. r. maculatus*. This phase is also represented under various names (*vide infra*) in Uganda, the Semliki Forest district, Nigeria, and the Spanish Gaboon. It occurred to me that the *punctatus* group represented a peopling or re-peopling of the forest from the Savannah country, and that thus two widely different forms of one squirrel occurred in one small area.

I then compared (with types when available) all the squirrels of this saturate group in the collection and plotted them on a map. The forms represented are *H. r. maculatus*, *H. r. obfuscatus*, *H. r. semlikii*, *H. r. nyansæ*, *H. r. pasha*, and *H. r. aubryi*, and some specimens from Uganda. Certain of the specimens labelled as above from localities adjacent to those of their respective types were evidently less saturate in colour, and it became evident that locality apart some of these forms could not be separated from those of the widely-spread group of forms separable with difficulty, if at all, from *H. r. rufobrachium*, a form of medium saturation originally described from Fernando Po.

The deeply saturate large forms referred to above occur in patches, these patches corresponding well with the distribution of heavy rainfall and rain-forest. Surrounding these areas and occupying the much larger area of forest where rainfall is roughly 60 inches or less, we find squirrels of the group just mentioned which correspond well with the type of *H. r. rufobrachium*.

These again are represented each in its own neighbourhood wherever the "bush" is thinner and ground lower by forms which are slightly smaller and paler, but which intergrade completely with the corresponding more saturate forms. Thus, in Nigeria we have *H. r. isabellinus*, in Fernando Po *H. r. acticola*, in Portuguese Guinea *H. r. caurinus*, in the Lower Congo *H. r. lualabæ*, in the Ubanghi *H. m. cænosus*, and specimens from the Uele which seem to correspond with Allen's *H. r. medjianus*.

The connection between the rain-forest forms and the little pale squirrels of the Savannah is thus complete. I realised that my previous idea of re-peopling of the forest area from the Savannah was wrong, and that in fact the distribution of the various forms of this squirrel is radial as well as zonal. That in fact the various forms, not only belong to one species but are all climatic variations of one squirrel. Like localities, *i. e.* those

in which rainfall, vegetation, temperature, altitude are the same, produce like forms of this squirrel irrespective of their precise geographical situation.

Examples of this can be multiplied indefinitely. Compare, for example, *H. m. kaffensis* from the Charada Forest (6.11.1.23) with *H. r. benga* from Spanish Gaboon (23.3.3.20), or *H. r. loandicus* (73.12.16.19) with *H. gambianus* (11.7 22.4) (Pl. I. figs. 1–4).

In order to test this conclusion, I selected about half-a-dozen of each phase—*i. e.* saturate forms, semi-saturate forms, small forest forms, and those from Savannah country, choosing such specimens in each phase as came from localities widely separate within the area of the group and matching closely in appearance. As the result of this work I found that not only do the several forms of each phase match remarkably closely, but that corresponding localities resemble each other in climate and vegetation. In other words, it is possible to infer with fair accuracy from an inspection of an individual specimen of the species, not indeed in many cases the geographical locality, but the type of country from which it comes.

Similarly it is possible, though highly laborious, to select from the localities represented in the collection a series from different parts of Equatorial Africa in which environmental conditions are known to be alike, when the corresponding specimens will be found to resemble each other, whether the various localities be north or south of the Equator or east or west of Africa. An exact knowledge of conditions of climate, vegetation, precipitation, and altitude of any given locality will enable a fairly precise description to be foretold of the *Heliosciurus* found there.

While there is complete intergrading throughout the whole range of variations of this animal, there are so many forms that it will be convenient to keep to certain groups in discussing such questions of nomenclature as now arise.

(1) The "*gambianus* phase" covers pretty accurately the forms once labelled "*annulatus*." These are the little grey or light brown squirrels of the "orchard bush" and tropical grassland.

(2) The "*punctatus* phase," small dark squirrels of relatively cold coloration from secondary and marginal forest.

(3) The "*rufobrachium* phase," in which it has been customary to include all medium-sized forest *Heliosciurus* with rufous tinging on the limbs. This is such a large group that we may subdivide it:—

(*a*) Relatively pale, lowland forest forms: *isabellinus, abassensis, hardyi*.

(*b*) Forms of medium saturation such as *rufobrachium*.

(*c*) Semi-saturate forms: *benga, kaffensis*.

(*d*) Saturate forms: *maculatus, nyansæ*.

(*e*) Mainly hill forms from the region of the Great Lakes and eastward: *mutabilis, rhodesiæ, undulatus, keniæ*.

1. *The "gambianus" Group. Small pale Savannah forms.*

Typically represented by *H. gambianus* Og., which is the type and, in my view, the only species of the genus. Its locality is the Gambia. It is a well-known grassland squirrel, and ranges westward to the Northern Territories of the Gold Coast, possibly through Nigeria.

It is variable in colour within certain limits, being yellowish grey rather than brown in the open grassland and warmer brownish in "orchard bush." The under surface is pretty uniformly white; only rarely does a specimen show a trace of the rusty tinge of the perianal region so characteristic of the more western forms of this phase of the squirrel.

An open grassland and consequently greyer and paler form from slightly to the North has been described as *H. g. senescens* Thos. from Senegal.

On the eastern side this animal is represented in Abyssinia by *H. multicolor* Rüpp., recognisable from *gambianus* by its somewhat larger size, and by the under surface being covered with hairs which, instead of being white, are "buffy" or pale reddish throughout, and by its generally somewhat brighter colouring. This hill "*gambianus*" might equally well be included in Group 4, Eastern Hill forms.

Between this, from the neighbourhood of Lake Tsana, and the western *gambianus* we have a complete series of connecting-links. In Uganda the grassland squirrel is *H. m. elegans* Thos., like *multicolor* but with most of the under surface white, only the base of the tail and the perianal hairs retaining a strong rusty-red colour.

This grades naturally into the very similar but slightly smaller *H. bongensis*, of the Bahr el Ghazal to the Shari. Intermediate forms between these two have been described: *H. m. madogæ* Hell. and *H. m. lateris* Thos. I can find no character or combinations of characters to separate the former from *bongensis*, and the latter, differing only very slightly in size, may, unless a large series show a constant difference unnoticeable at present, be regarded as included in *bongensis*. The type-locality of *lateris*, Lado, is in the *bongensis* area. *H. bongensis* is distinguishable from *gambianus* by the tawny or rusty tint of the base of the tail (under surface) and perianal region, which is usually absent in the western form, and by a slight difference in colouring on the back and sides; the light bands on the hairs of the upper surfaces are slightly more yellowish in *gambianus* than in *bongensis*, in which they are whitish or biscuit-coloured. A subspecies of *H. bongensis* has been described to indicate the slightly paler more northern form from drier grass country.

Farther west, still keeping to Savannah country, we have *H. g. limbatus* Schwarz. I have not seen this form, but from its description this is an intermediate form between *bongensis* and *gambianus*; it is unfortunate that so far no material is available

from Northern Nigeria, but when this becomes available it will probably be found to link up these forms.

The corresponding grassland forms to the south of the main forest are of peculiar interest. Here, as I have pointed out above, the squirrel, faced with conditions similar to those obtaining to the north of the rain forest, has reacted in a very similar way; indeed, many examples of the western low grassland squirrel known as *H. rhodesiæ loandicus* cannot be distinguished from *H. gambianus* (Pl. I. figs. 3 & 4).

Passing farther east, in the highlands of North Rhodesia we find this plains form merging into the hill form of "*loandicus*," a larger, greyer squirrel with relatively thick and long fur, *H. rhodesiæ*. This was originally and, as I believe, rightly described by Wroughton as *H. annulatus rhodesiæ*; "*annulatus*," of course, has now given way to *gambianus* (Thomas, Ann. Mag. N. H. [8] iv. 1909, p. 101).

H. rhodesiæ passes imperceptibly through such forms as *H. m. shirensis* and the other cold grey specimens into *H. mutabilis* of Nyasaland, a large squirrel whose pelage and colour suggest open country, or open temperate forest, at a considerable altitude and with marked seasonal changes in temperature

The most striking differences between the northern and the southern series of these grassland or Savannah forest squirrels is seen in the eastern forms, which in the north tend to show a warmer coloration, especially of the underparts, than those of the southern series. Thus while *gambianus* and *loandicus* seem inseparable, *rhodesiæ* can be told at a glance from *multicolor*.

2. *The "punctatus" Group.*

Of the small dark squirrels from secondary and gallery forest, other than those of the *isabellinus* phase (*vide infra*, 3 *a*), we have *punctatus* Temm. from Upper Guinea and *emissus* Thos. from S.E. Nigeria, closely alike but separable by the warmer coloration of the belly of the more eastern form; the under surface of *emissus* is washed with ochraceous, while in *punctatus*, especially in adult specimens, it is usually cold cindery grey. *H. emissus* is found to the east as well as to the west of the type-locality of *H. m. cœnosus* Thos.; a skin of *emissus* from the east was wrongly identified with *cœnosus* in the original description of that form. It is that of a fully adult animal smaller than *cœnosus* and of different coloration, matching in all respects perfectly with that of the type of *emissus*.

3. *The "rufobrachium" Group.*

(*a*) The "*isabellinus*" *phase*:—The relatively pale lowland phase of the "*rufobrachium*" group has been given various names in different localities. In West Africa we have *acticola* in Fernando Po, *caurinus* in Portuguese Guinea, and *isabellinus* in Nigeria. In Central Africa the Ubanghi has *H. m. cœnosus*

and the South Congo *H. lualabæ*. In the North-east these are represented by *H. m. abassensis* and *H. m. omensis*.

*H. r. isabellinus, r. caurinus, r. lualabæ,** and *m. cænosus*.—I have looked in vain in the original descriptions and at the available material in the collection for an indication of any character by which these four are to be distinguished one from another. I regard them as identical. That the form is a fairly widespread one seems evident from the facts that the type of *isabellinus* Gray, which was without locality, was at one time identified with an Angolan squirrel (no doubt that now named *H. r. loandicus*) and at another time with some from Nigeria. Nigerian specimens of this phase match very well with the series of skins from Ubanghi and from Luluabourg, Kasai (vide infra, *H. r. aubryi, H. r. lualabæ*). It is a form which will be likely to crop up as collecting progresses in suitable localities in most parts of Equatorial Africa, a more or less lowland, wet secondary forest form linking the *punctatus* group with the larger, more saturate true *H. rufobrachium*.

It is possible to distinguish these, as Thomas has pointed out, from the Fernando Po *H. r. acticola*, the latter showing somewhat warmer coloration, especially on the fore-limbs. *H. r. acticola* is the name given by Thomas to the pale and sea-level form of the Fernando Po *H. rufobrachium*. I think, however, that the question is worth facing whether two forms of this squirrel from Fernando Po should be recognised any longer.

No doubt Thomas is right in ascribing the type of *rufobrachium* to the forests of the hills. And no doubt certain relatively pale specimens are to be found, perhaps constantly, near the sea-border. An examination, however, of the series available in the collection of the two forms shows that the extreme difference is so slight, that one might hazard the opinion that if the whole material were mixed up, each labelled only with a number, no two observers, however competent, would sort them into their two groups in even approximately the same way.

Further, you may match almost any one of them from the Uele, or from Gabun. It is not as if you were dealing, then, with a form which shows, in howsoever slight a degree, differences which are constant for a locality and which enable any average specimens of it to be accurately placed in a certain locality. It is in my opinion by no means certain that these relatively pale forms are absolutely confined to near the sea-level on the island itself.

(*b*) *The "rufobrachium" phase*:—The Central African and Guinea forest squirrels of the "*rufobrachium* group" other than the saturate forms considered below are *H. r. rufobrachium* from Fernando Po, *H. r. leonensis* from Sierra Leone, *H. r. pasha* from the Uele, *H. r. aubryi* from Gabun.

Besides those named above we are bound to include in this group the North-eastern *H. m. kaffensis* from the Charada Forest.

* The relationship of *lualabæ* is discussed more fully below.

No one could examine a series of *H. r. benga* from Spanish Guinea (T.L. Cabo San Juan) and of *H. m. kaffensis* together, skulls or skins, without gaining the conviction that two distinct forms could hardly resemble one another more closely.

H. r. rufobrachium Waterh., T.L. Fernando Po, is well known and needs no description here. It is a semi-saturate medium-sized squirrel, with the ochraceous or ruddy colouring found on the limbs in so many forms of this squirrel, and which of course gave the trivial name, rather pronounced.

Three members of this section of the "*rufobrachium*" group require special notice, namely:—

H. R. PASHA Schwann, A. M. N. H. (7) xiii. 1904, p. 72.

Summing up the relationship of this form from the Uele, Schwann, in his original description, wrote: "This subspecies, allied to *H. r. nyansæ*, is more strongly suffused with rufous on the back and base of tail, while it is of a much brighter colour on the feet and belly. *H. kaffensis*, from the other side of the Nile, differs by 'die schöne rostfarbene' annulation of the caudal hairs. It may be mentioned that an allied form from S. Nigeria is also remarkable for the almost naked condition of its under surface, but is distinguishable by the absence of any rufous colour on the limbs."

The S. Nigerian form referred to is no doubt that now known as *H. r. isabellinus* Gray. Between this and the heavily saturate warm-coloured *H. r. obfuscatus* Thos. there occurs a complete series in Nigeria, of which those showing a medium degree of saturation have rufous on the limbs and cannot be picked out from topotypical *H. r. rufobrachium*.

To my eye, specimens from near the type-locality of *H. r. pasha* match well with some of the Fernando Po skins (compare, for example, 4.7.1.88. *H. r. rufobrachium* from Mt. Banterberi, Fernando Po, with 87.12.1.32. *H. r. pasha* from Bongereh).

The fact seems to be that many of the described forms of this squirrel vary each within its own district to an extent which makes it possible to match exactly or almost exactly individuals from very widely separate areas.

However, if a series of skins of *H. r. pasha* from the Uele be put with a series of skins of *H. r. rufobrachium* from Fernando Po and Nigeria, it will have to be admitted that in many cases it is not possible to sort them out without reference to the labels. Typical *rufobrachium*, in fact, is not confined to Fernando Po but extends across the whole rain-forest-belt in suitable localities (*vide* 11.12.3.59, Metalamaria, Uganda, Pl. IV. fig. 1; 6.11.1.25, Kalo Limo, N.E. Africa, Pl. IV. fig. 2). Further evidence of this is available from a consideration of the following two forms:—

H. r. leonensis was described by Thomas as "like *caurinus*, but more strongly coloured throughout." This appears to

suggest a connection with *H. r. rufobrachium*, and a comparison of a series of skins shows that *H. r. leonensis* cannot be distinguished from examples from Nigeria; it represents an intermediate form between *H. r. obfuscatus* and *H. r. isabellinus*, is not distinguishable from less saturate forms of the one or from dark forms of the other (*vide* No. 10.6.1.26 from Nkani, 28 miles N.E. of Oban in S. Nigeria (Pl. II. fig. 1), and 2.11.2.12 from Degama, S. Nigeria). In other words, it is indistinguishable from what corresponds in Nigeria to *H. r. rufobrachium*. If we now compare specimens from the type-locality Fernando Po with the Sierra Leone form, we find skins which match *leonensis* in every respect (*vide* 4.7.1.87 from Clarence Mt. in Fernando Po), though some of the Fernando Po series have the throat-patch coloured lighter due to absence of the few coarse, dark hairs seen among the white hairs in some Fernando Po and all Sierra Leone specimens that I have seen.

H. R. AUBRYI M.-Edw.

The specimens in the B.M. collection labelled as above vary so much among themselves and come from such widely separated localities, that it is necessary to sort them roughly into groups before attempting any comparison with other recognised forms. We do so as follows:—

(1) Specimens from the Benito River are relatively dark-bellied, and correspond very well with a topotypical specimen of *H. r. benga*.

They should be referred to that form.

(2) Skins from Luluabourg, Kasai, are all light-bellied, and in some cases the whole under surface is white. As mentioned above, these match both with *H. r. lualabæ* Thos. from Lota and with *H. r. isabellinus* from Nigeria. Their identification is further discussed below.

(3) Specimens from the Gabun; from Bitye, S. Kamerun; and from Kabambai, Kasai, S. Congo. These form a group of which adults resemble *H. r. rufobrachium* from Fernando Po very closely.

I have not seen the type of *H. r. aubryi*, but from the measurements given in the original description, which was based on one specimen from the Gabun only, it seems evident that the specimen in Milne-Edwards's hands was an immature animal. There happens to be a specimen from the Gabun in the B.M. collection (No. 80.6.7.6) which corresponds well with the description "Les côtés du museau, la gorge, l'abdomen et la face interne des membres sont couverts de poils blancs et peu serrés," and which is certainly immature. The differences which Milne-Edwards held to separate this form from others are not perceptible in mature specimens.

There is perhaps evidence of a slight tendency in the Gabun skins to show a lighter colour on the throat and chest than

appears usual in Fernando Po specimens. In the Gabun, however, the animal is as variable as it is elsewhere, and in the absence of any constant character by which to distinguish them, I think these skins from the Gabun should be identified with *H. r. rufobrachium* *.

There is, of course, the question whether even if no constant character can be found by which adults of these two can be distinguished one from another, it may be possible to separate immature forms; for example, if all immature forms from Gabun have white under surface and those of Fernando Po have not. In the B.M. collection there is not sufficient material available to settle the question, but the suggestion seems improbable. It may very probably be true that Gabun forms show a more marked tendency than those of Fernando Po to develop white patches at various stages of their growth, but this would hardly by itself constitute a character of subspecific worth.

Partly to test the correctness of my identification of *H. r. pasha* and *H. r. aubryi* respectively with *H. r. rufobrachium*, I laid out the two series together. It was then evident at once that the resemblance is so striking that it is not easy to imagine on what grounds they were originally separated; it seems probable that Schwann was relying on the original description of *H. r. aubryi* rather than upon an adult series.

But the conclusion is hard to resist that subspecies of this squirrel have been made from time to time on the assumption that because a given climatic phase seemed recognisable as a definite local race within a restricted area, it must necessarily be so within the whole range of the species.

H. R. LUALABÆ Thos.

By a singular chance this southern fringing forest form was described by Thomas from an immature specimen (*vide* tables) and its description suits equally well that of the type of *aubryi*. For Thomas, evidently comparing his animal with an adult series of *aubryi*, wrote "that it could be distinguished from *H. r. aubryi*" by its small size and the whitish median area of its under surface—just the main points on which *H. r. aubryi* was originally separated from other then known forms. A comparison of the type of *H. r. lualabæ* with the skin quoted above of *aubryi* (No. 80.6.7.6) from the Gabun will show at a glance the resemblance.

Adult skins of *lualabæ* differ, however, markedly from the Gabun skins. They match with skins from Luluabourg, Kasai, wrongly labelled *aubryi*, and all skins from this neighbourhood, *i. e.*, not far from the type-locality of *H. r. lualabæ*, available may be placed and lost among a series of *H. r. isabellinus*.

H. r. lualabæ must be regarded as a synonym of *H. r. isabellinus*.

* Since writing the above I have seen the statement in Jentink's Monograph that Milne-Edwards himself later regarded this form as a young *rufobrachium*.

(c) *The "benga" phase.* (*More or less saturate forms—H. r. benga, H. r. obfuscatus,* and *H. r. kaffensis.*)

H. r. benga Cabr. from Spanish Guinea was described as resembling *H. r. rufobrachium*, but smaller, and with more pronounced reddish suffusion on the upper surface. "Parecido a la subespicie tipica, pero más pequeño y con las partes superiores más rojizas, extendiendose este matiz sobre la cola en toda la extensión de la misma, en vez de limitarse a la base."

For smaller we should no doubt read "larger," as the dimensions given of the type-specimen seem slightly larger than those of average *H. r. rufobrachium*. The small series in the British Museum appears to be about as in *H. r. rufobrachium*.

The reddish suffusion described seems fairly constant, and in conjunction with the relatively dark belly of the squirrel, as compared with that of the typical subspecies, distinguishes it from all neighbouring forms, unless it be from the more saturate specimens from the forests of the Gabun, or from the Cameroons. But it must be borne in mind that this will not be found to be the only form met with in Spanish Guinea any more than it is confined to that district, and specimens which may resemble typical *rufobrachium* or even *isabellinus* should not be labelled *H. r. benga* merely because they come from Spanish Guinea.

As noted above the Charada Forest Squirrel, *H. m. kaffensis*, bears a singularly close resemblance to *H. r. benga*.

The coarser white speckling of the upper surfaces notably over the flanks, which characterises several of the North-eastern forms as compared with those from the West (see *abassensis* or *omensis* as compared with *rufobrachium* or *isabellinus* respectively), is also present in *kaffensis*, and will probably be found to separate it from the Spanish Guinea forms in most cases. (*H. r. kaffensis* is of course merely a slightly darker forest-form of *abassensis*.) The point holds good at least for the small series available in the B.M., and will no doubt prove to be pretty constant. A difference, on which I am not inclined to lay much stress, is the tendency shown by the Charada-forest form to have the light patch over the chest of a purer and more vivid white and somewhat more extensive than in *H. r. benga*. It is a very variable character (vide supra, *H. r. aubryi*).

On the whole, *H. r. benga* should be regarded as a recognisable phase of the squirrel somewhat more saturate in colour than in typical *rufobrachium*, and with more strongly marked rufous suffusion of the upper surfaces than in the other more saturate forms such as *H. r. maculatus*, *H. r. nyansæ*, etc.

H. r. obfuscatus was described in 1923 by Thomas to accommodate the more or less saturate form from Nigeria (Oban district). It is darker and more deeply coloured than typical *rufobrachium*; from *maculatus* it is distinguishable by its marked suffusion of ochraceous on the upper surfaces, best seen perhaps in most specimens in the proximal half of the tail, and by greater uniformity of colouring over the under surface; the reddish of

the limbs is rather less pronounced, and the dark bases of the hairs which, showing through the sparse covering of mid-belly and front of chest, make a definite dusky patch in *maculatus*, are smaller and the dusky patch is absent or much less pronounced in *obfuscatus*. These characters prove constant, but apply to other than the Nigerian dark form. They are matched well in squirrels from the Cameroons, Spanish Guinea, and the Gabun. I have compared specimens from all these areas with the type in the B.M. and find good matches in each case. I would draw especial attention to the following specimens:—

12.10.28.43. *H. r. obfuscatus*. Oban, Nigeria (type-locality).
23. 3. 2. 1. *H. r. benga*. Cabo San Juan, Sp. Guinea (type-locality).
7. 1. 1.62. *H. r. aubryi*. Gabun.
93. 1. 1. 4. *H. rufobrachium*. Barombi, Cameroons.

These four peculiarly saturate examples of this phase, evidently from areas of dense forest and high precipitation, approach *maculatus* in the brightness of the red on the limbs, but in the other characters agree with the type of *H. r. obfuscatus*, which evidently belongs to the same phase.

I have not seen the type of *H. r. benga*, and some specimens from the type-locality in the Museum show somewhat lighter coloration than the above quoted examples. This applies also to the other areas from which we have specimens (Nigeria to the Gabun); it must be continually borne in mind that within the limits of a small district the average annual rainfall, and the character of vegetation, and the altitude may vary very considerably.

H. r. obfuscatus should be regarded as a synonym of *H. r. benga*, which form will include saturate specimens from Gabun to Nigeria.

(*d*) *The "maculatus" phase.*

This form leads us naturally to the next group, in which the response of the species to forest condition reaches its climax. These magnificent squirrels, almost black above, with more or less dark under surface contrasting strongly with the deep reddish of the limbs, inhabit those patches of high rain-forest on which the mean annual rainfall is not much less than 60 inches. They have been given various names, but may now, with all the material available in the B.M. collection, be separated into two subspecies only—the Western or Upper Guinea form, *H. g. maculatus* Temm., and the Eastern form from the vicinity of the Great Lakes, *H. g. nyansæ* Neum. Further material than was available at the time of description suggests that the differences relied on by Thomas to separate the Semliki-forest form (*H. r. semlikii* Thos. A. M. N. H. xix. 1907) from *nyansæ* break down on series. It is true that the type-specimen, which remains the only one in the collection, cannot be quite precisely

matched by any one specimen from other localities, but the closely similar form from the forests of the north of Victoria Nyansa is found again in the west of the Semliki (vide *H. r. rubricatus*), and the fine speckling and grey as distinct from rufous suffusion of the dark back is found in some of the slightly paler forms from Uganda. Neumann himself appears to have been of this opinion, as he included in his original description the forests of the Semliki as part of the habitat of this squirrel:

"Vorkommen: Nordhälfte der Ost- und Westküste des Victoria-Nyansa und Länder bis zum Albert- und Albert-Edward See. Von Emin und Stuhlmann bei Ntebbi und Ussi in Uganda, Karevia, Okonjo und Kinjawanga . . . . . gesammelt."

J. A. Allen has described in his *H. r. rubricatus* what appears to be the same squirrel. At all events, a topotypical specimen which seems to correspond well with Allen's description matches with a specimen from Uganda. (Compare 14.2.11.4, Avakubi, Pl. III. fig. 2, with 99.8.4.49 from Entebbe, Uganda, and other specimens from near this locality.)

4. Finally we have the squirrels inhabiting the great block of hilly country to the east and south of the Great Lakes. In the north, around Lake Tsana, we have the little *multicolor*, closely akin to *gambianus*. In the south *mutabilis* fades imperceptibly into *rhodesiæ*, and so into the lowland pale phase *loandicus*.

Between *multicolor* and *mutabilis* we have *undulatus* True, from Mt. Kilimanjaro and its neighbourhood, and of this various subspecies have been described. It forms a good link since it is almost equally as difficult to define it from *mutabilis* as from *multicolor*.

Compare for instance:—

8.1. 1.59.	*mutabilis*.	Gorongoza Dist., P.E.A. (Pl. IV. fig. 3).
10.9.22.19.	*undulatus*.	Kwali Forest, Shimba Hills, B.E.A. (Pl. III. fig. 1).
2.9. 9.15.	*multicolor*.	Lake Tsana (Pl. IV. fig. 4).

In his original description of *undulatus*, Proc. Nat. Mus. xv. p. 467, 1892, True says it "appears to resemble *S. annulatus* and *S. punctatus* as described in Dr. Jentinck's monograph of the African Squirrels, but I am unable to associate it with either."

One must suppose that True overlooked *mutabilis* because of the unfortunate circumstance that the type of that squirrel appears to have been described from one of those rare atavistic individuals possessing five teeth in the upper molar series. This character, which is of course normal in *Æthosciurus*, occurs as a rarity in any race of *Heliosciurus*. Kershaw reports a case from Kasai ("*H. r. aubryi*," the skull of 776 has an extra premolar p.m.3 very small on each side of the upper jaw). It would be incredible otherwise that True would have given more than subspecific rank to a squirrel of which the most extreme examples

differ from *mutabilis* so little and only by a character of trifling importance, colour, which intergrades completely with that of the Nyassaland race.

Subspecies of H. undulatus.—From Kilimanjaro we have *H. undulatus* True and *H. u. marwitzi* Müller, from "the Mobaca R." *H. u. daucinus* Thos., and from Mafia Island *H. u. dolosus* Thos. Further, Heller described *H. r. shindi* from the summit of Mount Umengo, as "the most closely related to *Heliosciurus rufo-brachiatus undulatus* of Kilimanjaro, but differing in having paler underparts, buffy-ochraceous in tone without the rufous cast of that form. The dorsal surface is lighter with less black lining than in *undulatus*, the feet differ in being ochraceous and never as dark as the rufous of *undulatus*. There are no apparent differences in size and proportion of parts." (Smiths. Misc. Coll. vol. lxiii. no. 7, p. 7, 1914.) I have not seen an example of this phase; it would be of interest to know how it differs from "*H. mutabilis mutabilis*."

It is of interest to note in passing the fact that Heller regarded *undulatus* as a subspecies of *rufobrachium*.

H. undulatus True has "general colour rusty-grey above; bright rust colour below and on the feet." It is found on series to be variable. I have not seen the type of *H. u. marwitzi* Müller, also from Kilimanjaro, but specimens in the B.M. collection from that mountain seem to fit his description well and intergrade perfectly with that answering to True's description. I think *marwitzi* must be regarded as a synonym of *undulatus*. *H. u. daucinus* was described by Thomas to define the more brilliant, redder lowland form from Mombasa. There is only one specimen, the type, available, and pending further material it is not possible to give an opinion as to whether a large series will or will not enable us to identify this form with *undulatus* True. The type of *daucinus* at present remains clearly distinguishable by its red head.

H. u. dolosus of Mafia Island is a very interesting form in which the more or less brilliant rufous of *undulatus* True is replaced by dusky brown. The animal closely resembles *emissus*, but is larger. The general dark tone of the animal, especially the dark under surface, may perhaps be correlated with the fact that Mafia Island seems not to be subject to the same long dry season as obtains on the mainland. It or a similar dusky form will no doubt be found to occupy the whole coastal forest strip on the adjacent mainland.

Subspecies of H. mutabilis *Peters*, 1852.—The following have been separated from the typical subspecies: *shirensis* Gray, 1867, from the Shire River; *beiræ* Roberts, Beira, and *chirindensis* Roberts, from the Chirinda Forest.

Mr. Roberts does not define in his original description the difference between his specimens from Beira and those from the Shire River. I have been unable to find anything in the original

descriptions, or in comparisons of specimens from the respective (and adjacent) type-localities to justify their separation.

H. m. chirindensis was separated from *beiræ* by Roberts "by its more bushy tail." It "is intermediate in colour between the grey specimens from Beira and the light red ones from Boror, and in addition is brighter coloured on the under surface, the throat and sides particularly being richly coloured with orange-yellow." The "bushy tail" is found wherever in its somewhat extended recognised range this Mozambique and Nyassaland squirrel encounters highlands. Mr. Roberts is not clear as to which (or both) of the sets of specimens he refers to (*i. e.*, that from Boror or that from Beira) as distinguishable from the Chirinda Forest animal by their less bright under surface; but specimens in the B.M. collection from Boror and from many other localities in the range of "*H. m. mutabilis*" match very well with the most brightly coloured Chirinda Forest skins, and some specimens from the latter locality show a light under surface throughout very like that of most of the Shire River specimens.

I have not seen the type of *H. mutabilis* Peters from Boror, but from its description it is a darker animal than that usually found on the lower Shire River and to the south of it. Topotypical specimens in the B.M. series support this.

This phase is a notoriously variable one in colour; it is peculiarly liable to patchy bleaching while the deeper colourings of the hairs on the back and sides range, in specimens from the same neighbourhood, from light fawn or rufous to chocolate and even to sepia so deep as to be all but black.

In the absence of some further indication than is available from the series at present in the B.M. that the Chirinda Forest form differs in some constant character from those of the highlands of Nyassaland and Mozambique, it seems convenient to follow Jentink and recognise two forms only of this South-Eastern squirrel. These will be:—

H. g. mutabilis: darker above, belly more or less suffused with yellowish or dusky.

H. g. shirensis: lighter, often pale grey, above, belly and throat usually uniform whitish.

SUMMARY.

H. gambianus Og., the only species of this genus as at present restricted, inhabits the whole of Equatorial Africa. Its numerous forms are climatic phases.

It would follow from this that while some forms might be restricted to a definite single area, others would be found patchily in various and often widely separate areas. This proves to be the case, and the same form has been described by various names according to the particular area in which it was discovered. So that within a relatively small area which happens to include a variety of environmental conditions, "high-rain forest," "clearings," "orchard bush" and other types of Savannah forest and

grassland, such as Nigeria, or that area usually known as "Congo-Poko-Uele," several races of this species occur in close proximity, each of which races may crop up again and again in other similar but perhaps distant and quite unconnected localities.

The importance of this from the point of view of systematic zoology needs no emphasis. It is perhaps not too much to hope that work on something like these lines will eventually throw light on the physiological basis of reaction to climatic conditions, and so on the whole question of the formation of new species.

EXPLANATION OF THE PLATES.

PLATE I.

Fig. 1. *Heliosciurus multicolor kaffensis* Neum. Adult male. Charada Forest, Kaffa, N.E. Africa. Altitude 6000 feet; collected May 28, 1905. B.M. No. 6.11.1.23.

2. *Heliosciurus rufobrachium benga* Cabr. Adult female. Cabo San Juan, Spanish Guinea. B.M. No. 23 3 3.2.

3. *Heliosciurus gambianus* Og. Adult male. Talicon, French Gambia. Altitude 200 feet. Collected April 27, 1911. B.M. No. 11.7.22.4.

4. *Heliosciurus rhodesiæ loandicus* Thos. River Quanza, Angola. Collected May 1869. B.M. No. 73.12.16.19.

PLATE II.

Fig. 1. *Heliosciurus rufobrachium obfuscatus* Thos. Adult male. Nkam, 28 miles N.E. of Oban, S. Nigeria. Collected October 21, 1909. B.M. No. 10.6.1.26.

2 *Heliosciurus rhodesiæ* Wroughton. Adult male. N'dola, N Rhodesia. Collected April 27, 1910. B.M. No. 20.11.3.82.

3. *Heliosciurus rufobrachium aubryi* M.-Edw. Adult female. Como River, 75 miles from Gabun. Almost at sea-level. Collected July 9, 1897. B.M. No. 97 12.1 18.

4. *Heliosciurus bongensis* Heugln. Bahr-el-Ghazal. B.M. No. 7.10.2.10.

PLATE III.

Fig. 1. *Heliosciurus undulatus* True. Adult male. Kwali Forest, Shimba Hills, British East Africa. Altitude 1200 feet. Collected July 25, 1910. B.M. No. 10.9.22.19

2. *Heliosciurus rufobrachium semlikii* Thos. Adult female. Avakubi, Belgian Congo. Collected Nov. 11, 1912. B.M. No. 14.2 11.4.

3. *Heliosciurus gambianus senescens* Thos. Thiès, Senegal. Collected June 20, 1907. B.M. No. 9.11.2.14.

4. *Heliosciurus rufobrachium* Waterh. Adult female. Mount Banterberi, Fernando Po. Altitude 1800 metres. Collected March 11, 1904. B.M. No. 4.7.1.88.

PLATE IV.

Fig. 1. *Heliosciurus rufobrachium* Waterh. Adult male. Metalmaria, Uganda. Altitude 1200 metres. Collected August 3, 1911. B.M. No. 11.12.3.59.

2. *Heliosciurus multicolor abassensis* Neum. Adult male. Kalo, Lima, Abyssinia. Altitude 2300 feet. Collected May 2, 1905. B.M. No. 6.11.1.25 *.

3. *Heliosciurus mutabilis* Peters. Adult male. Tambarara, Gorongoza Mountains, Portuguese S.E. Africa. Altitude 1300 feet. Collected May 1, 1907. B.M. No. 8.1.1.59.

4. *Heliosciurus multicolor* Rüpp. Adult male. Zegi, Lake Tsana, Abyssinia. Collected May 14, 1902. B.M. No. 2.9.9.15.

EXHIBITIONS AND NOTICES.

March 22nd, 1927.

Sir ARTHUR SMITH WOODWARD, F.R.S., Vice-President, in the Chair.

The SECRETARY read the following Report on the Additions to the Society's Menagerie during the month of February, 1927:—

The registered additions to the Society's Menagerie during the month of February were 230 in number. Of these 209 were acquired by presentation, 4 were purchased, 13 were deposited, 1 was received in exchange, and 3 were born in the Menagerie.

The following may be specially mentioned:—

2 Emus (*Dromæus novæ-hollandiæ*), from Australia, presented by Alfred Ezra, O.B.E., V.P.Z.S., on February 3rd.

An East African Buffalo (*Bos caffer*), born in the Gardens on February 8th.

A collection of some seventy mammals, birds, and reptiles from Gambia, presented by Capt. Sir Cecil Armitage. K.B.E., C.M.G., D.S.O., F.Z.S., on February 15th.

1 Yak (*Bos grunniens*), from Tibet, presented by the President on February 18th.

A Tiger-cub (*Felis tigris*), from India, presented by Mrs. B. Taylor on February 26th.

Dr. J. BEATTIE, C.M.Z.S. (Anatomist to the Society), exhibited and made remarks upon, a series of Radiographs and Skulls showing the eruption of the permanent Dentition in the Chimpanzee and other Primates.

Mr. F. MARTIN DUNCAN, F.Z.S. (Librarian), exhibited, and made remarks upon, a series of Cinematograph Films he had taken in the Society's Gardens.

Mr. G. C. ROBSON, M.A., F.Z.S., exhibited specimens, and made remarks upon, the Seasonal and Sexual Dimorphism in the Squid *Alloteuthis subulata*.

April 5th, 1927.

Sir SIDNEY F. HARMER, K.B.E., F.R.S., Vice-President, in the Chair.

The SECRETARY exhibited, and made remarks upon: (1) the two volumes of the completed 'World List of Scientific Periodicals,' and (2) the first number of the American 'Biological Abstracts.'

Mr. E. G. BOULENGER, F.Z.S., exhibited, and made remarks upon, a Crab with abnormal claw.

April 26th, 1927.

Sir Arthur Smith Woodward, F.R.S., Vice-President, in the Chair.

The Secretary read the following Report on the Additions to the Society's Menagerie during the month of March, 1927 :—

The registered additions to the Society's Menagerie during the month of March were 149 in number. Of these 73 were acquired by presentation, 52 were purchased, 8 were deposited, 2 were received in exchange, and 14 were born in the Menagerie.

The following may be specially mentioned :—

2 Thick-billed Cardinals (*Pyrrhuloxia sinuata*), from Mexico, purchased on March 11th, new to the Collection; 1 Mexican Thrush-Robin (*Catharus mexicanus*), from Mexico, presented by G. B. Chapman, F.Z.S., on March 11th, new to the Collection.

2 Mexican Barred Partridges (*Philortyx fasciatus*), from Mexico, purchased on March 11th, new to the Collection; 3 Crested Grey Birds (*Ptilogonys cinereus*), from Mexico, purchased on March 11th, new to the Collection; 1 Bengal Red-capped Babbler (*Timalia pileata bengalensis*), from India, presented by Capt. H. S. Stokes, F.Z.S., on March 14th, new to the Collection.

1 Hybrid Lilford's and White-necked Crane (*Grus grus lilfordi* × *Pseudogeranus leucauchen*), bred at Guildford, deposited by Lord Rothschild, F.R.S., F.Z.S., on March 29th.

Sir A. Smith Woodward, F.R.S., recalled the fact that the first-recorded scientific Meeting of the Zoological Society was held on April 25th, 1827. It was reported in *The Times* of April 27th, 1827. Dr. Joshua Brookes, the eminent anatomist, had been invited by "the noble directors of the Society" to lecture on his dissection of the body of an ostrich which had lived for two years at Windsor, and at death had been given to the Society by the King. Lord Auckland, Lord Stanley, Dr. Birkbeck, and many others were present. In his general remarks, Dr. Brookes said "the period had arrived when the science of natural history bade fair to reach a height in this country which would enable us to rival the establishments founded for its promotion abroad."

Sir Arthur Smith Woodward, F.R.S., exhibited, and made remarks upon, a series of specimens and photographs of Cretaceous Fishes from the Lebanon.

Following a brief description of the experimental arrangements and procedure adopted, Dr. R. G. Canti exhibited a Cinematograph Film showing (*a*) the growth of cells of the periosteum of the Chick Embryo in the following stages:—Vegetative cell and its internal structures, cell undergoing division and degeneration, and (*b*) of cells in cultures of malignant tissue (Jensen's Rat Sarcoma) showing their special character.

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ZOOLOGICAL SOCIETY OF LONDON.

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Owing to the cost of printing, the Publication Committee beg to draw the attention of Authors submitting papers for publication by the Society to the following Regulations. If the conditions are not observed, papers may have to be returned :—

1. MSS. submitted for publication must be written in a clear and legible handwriting, or, preferably, be type-written, and must be in final form for printing. The MSS. should be written on one side of each sheet only, and the pages clearly numbered. All tables of contents, references to plates, or legends to illustrations in the text, etc., must be in their proper places, **with page and plate numbers left blank**; and the position for the text-figures must be indicated. References to literature must be exact, with the page number as well as the volume number and date.

2. Proofs and their Correction.—Two copies of the slip proof, and a page proof for final revision, will be sent to the Author, **but it is important that all serious corrections be made on the slip proof.** Expenses for proof corrections are very heavy, but, if the MSS. comply with Regulation 1, should not exceed 25 per cent. of the printers' charges. If the cost of corrections exceeds 25 per cent., a proportion of the excess will be charged to the Author.

3. Revised proofs must, if possible, be returned within one week from the date of their receipt by the Author.

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ZOOLOGICAL SOCIETY OF LONDON.

This Society was founded in 1826 by Sir Stamford Raffles, Mr. J. Sabine, Mr. N. A. Vigors, and other eminent Naturalists, for the advancement of Zoology and Animal Physiology, and for the introduction of new and curious subjects of the Animal Kingdom, and was incorporated by Royal Charter in 1829.

The Society consists of Fellows, Imperial Fellows, Honorary, Foreign, and Corresponding Members, elected according to the By-Laws. It carries out the objects of its foundation by means of its collection of living animals, by its Library, and by its Scientific Publications.

The Office of the Society, Regent's Park, N.W.8, where all communications should be sent, addressed to "The Secretary," is open from Ten till Five, except on Saturdays, when it closes at ONE P.M.

The Library, under the superintendence of Mr. F. Martin Duncan, F.R.M.S., F.R.P.S., F.Z.S., is open daily (except Sunday) from Ten A.M. till Five P.M.; on Saturdays, Ten A.M. till One P.M.

The Library is closed from Good Friday to Easter Monday, and upon all other Bank Holidays. It is also closed annually for cleaning during the month of September.

The Meetings of the Society for General Business are held in the Meeting Room at the Society's Office on the third Wednesday of the month at 4.30 P.M. except in September and October.

The Meetings for Scientific Business are held in the Meeting Room at the Society's Office fortnightly on Tuesdays, except in July, August, September, and December and January, at half-past Five o'clock P.M.

The Anniversary Meeting is held on the 29th of April, or the nearest convenient day, at Four P.M.

The Society's Gardens are open daily from Nine o'clock until Sunset, or 8 P.M. when sunset is later. Dr. G. M. Vevers is the Superintendent. Mr. D. Seth-Smith, Curator of Mammals and Birds; Mr. Edward G. Boulenger is Director of the Aquarium; Miss Joan B. Procter, F.L.S., is Curator of Reptiles; Mr. L. C. Bushby, F.E.S., is Curator of Insects; Dr. John Beattie, M.B., Ch.B., M.Sc., is Anatomist; Dr. H. H. Scott, M.D., F.R.C.P., D.P.H., Pathologist; Prof. R. T. Leiper, F.R.S., with the assistance of a panel of experts, examines and reports on the Parasites; Prof. G. H. Wooldridge, F.R.C.V.S., is Honorary Consulting Veterinary Surgeon; and Dr. R. W. A. Salmond, O.B.E., Honorary Radiologist to the Society. Applications for anatomical or pathological material, or for facilities for work in the Prosectorium should be addressed to the Secretary.

TERMS FOR THE ADMISSION OF FELLOWS.

FELLOWS pay an Admission Fee of £5, and an Annual Contribution of £3, due on the 1st of January, and payable in advance, or a Composition of £45 in lieu thereof; the whole payment, including the Admission Fee, being £50.

No person can be deemed a FELLOW until the Admission Fee and first Annual Subscription of £3 have been paid, or the annual payments have been compounded for.

The usual Admission Fee of £5 is waived upon the election of the WIFE or HUSBAND of an existing FELLOW.

The First Annual Subscription of Fellows elected in November and December covers the following year.

PRIVILEGES OF FELLOWS.

Fellows have Personal Admission to the Gardens upon signing their names in the book at the entrance gate, and may introduce Two Companions daily.

The Wife or Husband of a Fellow can exercise these privileges in the absence of the Fellow, but this privilege cannot be extended to children of Fellows.

Until further notice, Fellows will receive 40 undated Green Cards, available on any Sunday or week-day up to the end of February of the year following the year of issue, and 20 White Cards available on any week-day up to the same date. Special children's tickets are no longer issued, but the Green and White Cards are perforated, and each half is valid for a Child under twelve years of age. Additional Sunday tickets cannot be purchased or acquired. It is particularly requested that Fellows *will sign every ticket* before it goes out of their possession. Unsigned tickets are not valid.

Fellows are not allowed to pass in friends on their written order or on presentation of their visiting cards.

Aquarium.—Fellows have free personal admission to the Aquarium at all times when it is open. On Sundays, but not on week-days, they may introduce two visitors with them. These privileges are personal and cannot be transferred. For admission to the Aquarium of other friends whom they have admitted to the Gardens by Sunday tickets they may purchase from the Office books of 20 tickets for £1, or a smaller number at the same rate, each ticket admitting one adult or two children on Sundays or week-days. Fellows may also purchase a transferable Aquarium Ivory Ticket, for £10, valid for the whole duration of the Fellowship and admitting daily, on Sundays or week-days, two persons who have already gained admission to the Gardens.

Fellows have the privilege of receiving the Society's ordinary Publications issued during the year upon payment of the additional Subscription of One Guinea. This Subscription is due upon the 1st of January, and must be paid before the day of the Anniversary Meeting, after which the privilege lapses. Fellows are likewise entitled to purchase these Publications at 25 per cent. less than the price charged to the public. A further reduction of 25 per cent. is also made upon all purchases of Publications issued prior to 1881, if above the value of Five Pounds.

Fellows also have the privilege of subscribing to the Annual Volume of 'The Zoological Record,' which gives a list of the Works and Publications relating to Zoology in each year, for the sum of Two Pounds Ten Shillings. Separate divisions of volumes 39 onwards can also be supplied. Full particulars of these publications can be had on application to the Secretary.

Fellows may obtain a Transferable Ivory Ticket admitting two persons, available throughout the whole period of Fellowship, on payment of Ten Pounds in one sum. A second similar ticket may be obtained on payment of a further sum of Twenty Pounds.

Any Fellow who intends to be absent from the United Kingdom during the space of at least one year, may, upon giving to the Secretary notice in *writing*, have his or her name placed upon the "dormant list," and will then be called upon to pay an annual subscription of £1 only during such absence, or in the event of returning to the United Kingdom before June 30th in any year to pay the balance of the ordinary subscription. After three years a Dormant Fellow must make a further application to be retained on that list.

Any Fellow, having paid all fees due to the Society, is at liberty to withdraw his or her name upon giving notice in *writing* to the Secretary.

Ladies or Gentlemen wishing to become Fellows of the Society are requested to communicate with "The Secretary."

P. CHALMERS MITCHELL,
Secretary.

Regent's Park, London, N.W. 8.
June, 1927.

MEETINGS

OF THE

ZOOLOGICAL SOCIETY OF LONDON

FOR

SCIENTIFIC BUSINESS.

1927.

Tuesday, October............ 18.

——— November......... 1 and 15.

The Chair will be taken at half-past Five o'clock precisely.

ZOOLOGICAL SOCIETY OF LONDON.

LIST OF PUBLICATIONS.

The scientific publications of the Zoological Society of London are of two kinds—"Proceedings," published in an octavo form, and "Transactions," in quarto.

According to the present arrangements, the "Proceedings" contain not only notices of all business transacted at the scientific meetings, but also all the papers read at such meetings and recommended to be published in the "Proceedings" by the Committee of Publication. A large number of coloured plates and engravings are issued in the volumes of the "Proceedings," to illustrate the new or otherwise remarkable species of animals described therein. Amongst such illustrations, figures of the new or rare species acquired in a living state for the Society's Gardens are often given.

The "Proceedings" for each year are issued in four parts, paged consecutively, during the months of March, June, September, and December. From January 1901 they have been issued as two half-yearly volumes, indexed separately.

An "Abstract of the Proceedings" is published by the Society on the Tuesday following the date of the Scientific Meeting to which it refers. It is issued along with the "Proceedings," free of extra charge, to all Fellows who subscribe to the Publications, but it may be obtained on the day of publication at the price of Sixpence, or, if desired, sent post free for the sum of Six Shillings per annum, payable in advance.

The "Transactions" contain such of the communications made to the Scientific Meetings of the Society as, on account of the nature of the plates required to illustrate them, are better adapted for publication in the quarto form. They are issued at irregular intervals.

Fellows and Corresponding Members, upon payment of a Subscription of One Guinea *before* the day of the Anniversary Meeting, are entitled to receive the Society's Publications for the year. They are likewise entitled to purchase the Publications of the Society at 25 per cent. less than the price charged to the Public. A further reduction of 25 per cent. is made upon purchases of Publications issued prior to 1881, if they exceed the value of Five Pounds.

Fellows also have the privilege of subscribing to the Zoological Record for a sum of Two Pounds Ten Shillings (which includes cost of delivery), payable on the 1st of July in each year; but this privilege is forfeited unless the subscription be paid *before* the 1st of December following.

The following is a complete list of the publications of the Society already issued.

TRANSACTIONS OF THE ZOOLOGICAL SOCIETY OF LONDON

4to. 20 vols. and Index.

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Vols. I.–IV. (out of print).			
Vol. V., containing 67 Plates	(1862–66)	5 4 3	6 19 0
„ VI., „ 92 „	(1866–69)	11 5 0	15 0 0
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Vol. XI., containing 97 Plates	(1880–85)	9 12 0	12 16 0
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„ XV., „ 52 „	(1898–1901)	5 15 6	7 14 0
„ XVI., „ 38 „	(1901–1903)	5 8 0	7 4 0
„ XVII., „ 41 „	(1903–1906)	5 18 6	7 18 0
„ XVIII., „ 43 „	(1907–1911)	4 1 0	5 8 0
„ XIX., „ 24 „	(1909–1910)	10 4 0	13 12 0
„ XX., „ 53 „	(1912–1915)	11 10 3	15 7 0
„ XXI.—Part I. (7 Plates & 12 Text-figs.)	(June 1916)	2 5 0	3 0 0
„ XXII.—Part I. (Text-figures 1–13)	(December 1926)	1 17 6	2 10 0
„ „ —Part II. (Text-figures 14–76)	(March 1927)	1 17 6	2 10 0

In consequence of a re-arrangement of the stock of the 'Transactions,' the Society is now able to offer for sale, at the reduced price of £30, sets of Vols. V.–XVI. inclusive.

PROCEEDINGS OF THE COMMITTEE OF SCIENCE AND CORRESPONDENCE OF THE ZOOLOGICAL SOCIETY OF LONDON. 8vo. 2 vols. (Letterpress only).

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Part I. 1830–31. 1 vol. 8vo., out of print.			
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Parts I., VII.–IX., XI., XIV., XV., out of print.

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* 1908 out of print. † 1911 out of print.

CATALOGUE OF THE LIBRARY of the Zoological Society of London (Fifth Edition.) 8vo. 1902. Cloth, 6*s*.

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ZOOLOGICAL RECORD.—Vol. 62, containing literature relating chiefly to the year 1925, has now been published, price £3. Vol. 63, for the year 1926, is being prepared as usual, price £3, or subscription, if paid in advance, £2 10*s*. 0*d*.

P. CHALMERS MITCHELL,
Secretary.

Regent's Park, London, N.W. 8.
June 1927.

These publications may be obtained at the Society's Office *or through any bookseller.*

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Differentiation of the Retina in the Primates

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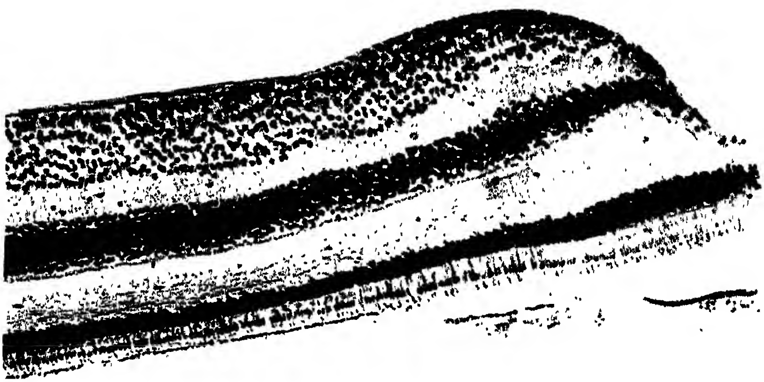

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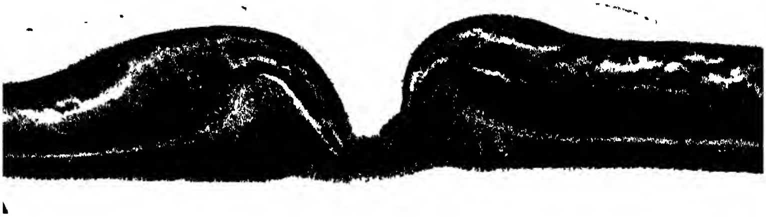
DIFFERENTIATION OF THE RETINA IN THE PRIMATES.



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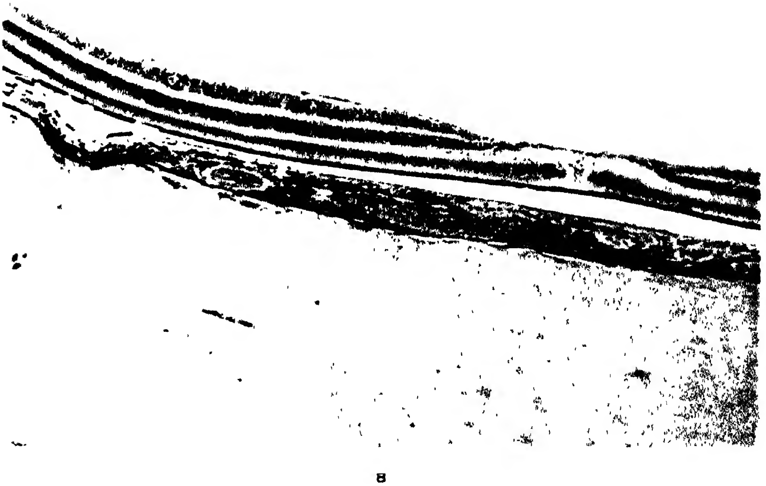

8

DIFFERENTIATION OF THE RETINA IN THE PRIMATES.

PROCEEDINGS

OF THE

GENERAL MEETINGS FOR SCIENTIFIC BUSINESS

OF THE

ZOOLOGICAL SOCIETY OF LONDON.

PAPERS.

1. The Differentiation of the Retina in the Primates. By H. H. WOOLLARD, Department of Anatomy, University College *.

[Received September 24, 1926. Read February 8, 1927.]

(Plates I.-IV.)

Aspects of evolution which have been brought forward by Prof. Elliot Smith,—the acquirement of skilled movements and the correlation of these with vision,—suggested that an attempt should be made to establish the degree of differentiation in the retina that might have occurred in different members of the Primate series.

The object of this study is to describe the changes which the retina has undergone in a closely-related series of animals as it has become an organ of greater visual acuity. For description three areas of the retina were chosen: a part adjacent to the ora serrata; a part in the equatorial plane of the eye; and finally the central area of the retina, the macular region. Franz (3) has drawn attention to the fact that in those animals which live wholly on the ground, such as the ungulates, the visual powers are best developed in the horizontal plane of the eye. In the arboreal animals, and this study deals almost entirely with them, the horizontal and vertical planes are equally developed, and this discrepancy between the two planes does not occur.

There are a number of features that may be used as measures of visual acuity. The number of sensory elements in the retina and the degree to which the supporting elements (such as the internal and external limiting membranes) are manifest have been suggested by Franz. In general the elements of the retina become

* Communicated by Prof. G. ELLIOT SMITH, F.R.S., F.Z.S.

more numerous as one passes through the different orders of vertebrates, culminating in birds on the one hand and in mammals, the anthropoids, and Man on the other. Experience soon showed that a better idea of the abundance of the elements is obtained by estimating the numbers of rows of nuclei than by giving their absolute measurements in the sections. In the two nuclear layers there is a great difference in the closeness with which the elements are packed together. Another point to be noticed is that the inner and the outer nuclear layers vary in abundance according to the nature of the sensory epithelium. When this layer is composed of rods the outer nuclear sheet contains more nuclei than the inner. The reverse is the case when the cones form the chief element of the percipient layer. The perfection of the lamination and the prominence of the supporting structures do not help much in such an investigation as this, for hardly any difference can be detected in the degree which this has reached in these animals.

A retina whose sensory epithelium is composed of rods is less efficient as an instrument for attaining the higher powers of vision. The low degrees of luminosity at which it functions must make the elementary sensation of movement the principal visual stimulus. Since such a retina represents a definite specialisation for a specific purpose, it is not directly comparable with that of a diurnal animal.

The presence of a macula and a fovea has the greatest physiological significance. Apparently a fovea is found only when cones are present. *Nyctipithecus* has been claimed by some writers to be an exception to this rule, but, as will be shown later, this is not the case.

The abundance of bipolar and ganglion cells must be of great importance in the attainment of visual acuity. These elements are most abundant when cones are the chief element of the percipient layer. The limits of visual acuity depend on the diameter of the cone. Theoretically, at any rate, if this degree of acuity is not to be impaired, each cone should have the specificity of its impulse preserved by being connected with a single line of conducting neurons. The recent work of Adrian (**1**) on the action currents of single sensory fibres makes it probable that the factor underlying the intensity of sensation is the frequency of the impulses set up. The anatomical basis of the intensity of sensation would be the number of conducting elements. In the cone retina these are far in excess of the number of percipient cells: but the reverse is the case in the rod retina.

The material used in the present study was obtained from the Zoological Society's Gardens in London. To the Society I wish to express my very great indebtedness for the facilities I have enjoyed. The study was only made possible by the co-operation of Dr. Beattie, the Society's anatomist, who collected the eyes and attended to their preliminary fixation. I am deeply grateful to him.

The material consisted of the following specimens. In order to make the study more complete, this list includes specimens which have been previously described. They are *Tupaia*, *Tarsius*, and *Hapale*.

INSECTIVORA: *Tupaia minor*.

LEMURIDÆ:
- *Lemur* (brown) ? *brunnea*.
- *Lemur niger*.
- *Lemur catta*.

LORISINÆ:
- *Nycticebus tardigradus*.

TARSIIDÆ:
- *Tarsius spectrum*.

CEBIDÆ:
- *Nyctipithecus*.
- *Cebus fatuellus*.

HAPALIDÆ:
- *Hapale jacchus*.

CERCOPITHECIDÆ:
- *Macacus rhesus*.
- *Cercopithecus callitrichus*.
- *Cercocebus fuliginosus*.

ANTHROPOMORPHÆ:
- Chimpanzee (*Anthropopithecus*).
- *Homo sapiens*.

The human eye was kindly given me by Dr. E. Woolf, who had removed it from a patient suffering from some chronic inflammation of the orbit. The exact nature of the disease was unknown. The eyes were fixed in Kolmer's fluid, consisting of formalin, bichromate and acetic acid. In the case of small eyes, simple immersion was sufficient to give an adequate fixation. In the case of the larger eyes, the injection of a small quantity of the fluid into the interior of the eye together with immersion sufficed for a preliminary fixation. When the eye was hard enough, the cornea and the lens were removed and the eye allowed to remain in the fluid for three or four days. The staining was done *in toto* with carmine, and then the eyes, after embedding in paraffin, were cut in serial section. The sections varied in quality. In the majority there was some displacement of the retina, especially in the macular region. Since the eyes had to be removed and fixed at varying intervals after death, complete success in fixation and staining could not be hoped for. However, the success obtained was sufficient for the purpose in view.

DESCRIPTION OF THE INDIVIDUAL SPECIMENS.

Tupaia minor.

This specimen has been described previously (**14**). The retina is that of a diurnal animal. The percipient layer probably contains cones with an outer nuclear layer of cells of three rows, and in the central area an inner nuclear layer some nine cells thick. There is, however, no macula or fovea. In view of the affinities of *Tupaia* with the Lemurs (Le Gros Clark, **9**), it is interesting that the retina has not undergone any nocturnal specialisation. This retina might be considered as a generalised form from which either the more specialised retina of the higher Primates or that of the nocturnal Lemurs could arise.

The Lemurs. (Pl. I. fig. 1.)

Unfortunately these specimens are rather imperfect. The most satisfactory for study was the retina of *Lemur niger*. The others did not repay close study: but they conform to that of *Lemur niger*. The retina of *Lemur niger* is in general thin and without differentiation. The amount of pigmentation is moderate and the percipient layer is composed wholly of rods. The most peripheral part of the retina is thin and measures 68 μ. In this peripheral part the ganglion layer consists of only a few scattered cells. The inner nuclear layer only comprises one or two rows of nuclei. The outer nuclear layer is somewhat broader and contains three rows of nuclei. The percipient layer is composed of rods only, and these are extremely elongate. The outer segment of the rod is nearly twice the length of the basal portion.

The inner molecular layer is narrow, but broader than the outer molecular layer. The pigment is moderate in amount. As the retina is followed towards the equatorial plane, it shows a gradual increase in the number of the elements composing it. Its width in section equals 170 μ. The inner limiting membrane is well marked. The ganglion cells form a single layer, but the cells now lie close together. The inner molecular layer is relatively broad. The inner nuclear layer has increased in thickness, but is not so prominent as the outer nuclear layer. However, compared with the same layer in *Nyctipithecus* it is much better developed. Five to six rows of nuclei are present and it measures 17 μ in thickness. The outer molecular layer is so poorly developed that the two nuclear layers are practically in contact. The outer nuclear layer is prominent, the nuclei are closely packed, and the staining appears, therefore, to be more intense. It measures 30–35 μ and contains about ten rows of nuclei. In the percipient layer there are rods but no cones. These are very elongated, but less so than in *Nyctipithecus*. The outer segment is only slightly longer than the basal portion. Compared therefore with the more peripheral part of the retina, the rods are less elongated. The central area preserves these same features. The elements undergo no accumulation that could be described as a macular formation. There is of course no foveal region. The middle and central portions of the retina are therefore of the same thickness. The only change noted between the two is that the rods become more elongated again in the central area. Throughout the retina the pigment layer exhibits only a moderate amount of pigment, this being much less than occurs in most nocturnal animals. The optic cup is slightly excavated and non-pigmented. The retinæ of the other Lemurs present the same features as in this case. The retina of *Nycticebus* happens to be poorly fixed: but such investigation as is possible shows that it conforms to the foregoing description except in the matter of pigmentation. It is much more heavily pigmented in keeping with the nocturnal habits of the animal.

The retina of *Tarsius* was described in a previous communication (**13**). It was shown that in the central area of the retina there was a great increase in all the elements of the retina, and, above all, visual acuity was enhanced by the formation of a macular area, in which an increase of the elements was obtained through the outer layers of the retina being thrown into folds. Among the Primates, so far as my observations go, this primordial macula is peculiar to *Tarsius*.

No previous histological investigations have been made on the retinæ of *Tupaia* or of *Tarsius*, and we have the authority of Franz (**4**) for saying that the retina of the Lemurs has not been investigated microscopically. The work of Lindsay Johnson (**7**) gives illustrations of the lemurine retina. He describes it as heavily pigmented and wanting in the development of any central area. Our observations agree with his results obtained by ophthalmoscopic examination.

The Retina of Nyctipithecus. (Pl. I. fig. 2.)

The retina is heavily pigmented. The ora serrata is quite smooth. The ciliary processes consist of a central space filled with blood. The blood-space is lined by endothelium, the cells of which occasionally contain a perinuclear ring of pigment granules. Immediately outside the endothelial layer there are scattered spheroidal cells containing a large amount of pigment. These cells are succeeded by a cellular mass so crowded with pigment that no details are discernible. The margins of the processes are lined by cubical cells free from pigment. These surface cells become continuous with the inner and outer nuclear layers of the retina.

The peripheral part of the retina is thin. The ganglion layer begins as cells that are widely separated. The intervals between the cells are approximately regular. The internal limiting layer is well defined. The inner molecular layer begins at once as a wide band of fibres. At the periphery the inner and outer nuclear layers are fused, but soon are separated by the formation of the outer molecular layer. The inner nuclear layer is the narrower of the two, and its staining appears to be less intense than that of the outer layer. This is due to the fact that the nuclei are much less closely packed together. The inner nuclear layer contains two rows of cells. Its borders are irregular, and scattered nuclei are found in both the outer and inner molecular layers. The outer nuclear layer is much the more prominent. The three rows of cells composing it stain more densely than the inner. The retina is heavily pigmented. The percipient layer is composed wholly of rods. Amongst the basal portions of these rods there lie scattered nuclei belonging to the outer nuclear layer. The pigment is so abundant that no details can be discerned of the cells of this layer. The total width of this part of the retina is 136 μ.

As the retina is examined nearer to the centre, the increase in thickness occurs rapidly. The increase in thickness is most manifest in the outer nuclear layer. The inner nuclear layer has slightly increased and numbers three rows of cells. The outer has become disproportionately large, and is composed of about twelve rows of cells most compactly arranged. The ganglion layer shows only a slight increase. The individual cells of this layer still preserve a considerable interval between them. The percipient layer is composed wholly of rods closely packed together.

In the central part of the retina near the optic nerve the gradual increase in its dimensions has raised the measurement to 204 μ. The ganglion layer remains one cell thick, but the cells are now close together and form a continuous layer, but even yet there are occasional gaps in the series. The inner molecular layer compared with the more differentiated eyes remains thin, but here is slightly wider than the outer molecular layer. The inner nuclear layer is five cells thick, and therefore somewhat increased beyond the size it attained in the middle portion of the retina. The conspicuous feature is again the size and compactness of the outer nuclear layer. The nuclear rows number about thirteen, and comprise nearly one-third of the total thickness of the retina. The percipient layer of the retina is composed wholly of rods. These are packed so closely that they account for the great increase of the nuclei composing the outer nuclear layer. The rods are extremely elongate, and the outer segment is about two and a half times the length of the inner portion. They are 68 μ long. Scattered granules from the pigment layer are found among the outer segments of the rods Between the outer segments of the rods there are clear oval spaces. These are probably artefacts. The outer limiting membrane is well defined. The optic disc is non-pigmented, oval, and projects slightly towards the interior of the eye. The summit of the disc where the artery enters is cupped.

The retina attains its maximum thickness on the lateral side of the entrance of the optic nerve. The increase is a gradual one from the periphery towards the centre. There is no macula formation, no fovea or plication of the outer layers. The central area is characterised by the small number of ganglion cells, the extreme narrowness of the outer molecular layer, and the very great number of nuclei in the outer nuclear layer.

Schultze (**10**) is quoted by Krause (**8**) as having examined the retina of *Nyctipithecus* microscopically. (Schultze's paper (1872) is not available to us.) According to Krause, Schultze found no cones and no yellow spot in the retina. Lindsay Johnson (**7**) says of *Nyctipithecus* that it is generally regarded as the lowest of the Platyrrhine Monkeys, and has a fundus stippled all over with minute brown dots. The appearance is very similar to that found in the Lemuridæ, so that, but for the great distinction due to the presence of a macula, *Nyctipithecus* approaches the higher

forms of the Prosimiæ, a coincidence due to their nocturnal habits.

My observations are not in agreement with the ophthalmoscopic observations of Johnson. Like Schultze, I have found no evidence of the existence of a macula microscopically. As already mentioned, *Nyctipithecus* is no exception to the rule that a true macula and fovea are only found when cones form the chief constituent of the sensory epithelium of the retina. These observations add support to the conception that *Nyctipithecus* is the most primitive of the Platyrrhines.

When it is considered how significant a rôle the development of the macula plays in the evolution of the Anthropoidea, it is a matter of exceptional interest to find the macula absent in a Monkey's retina, even though its nocturnal habits provide the explanation for the defect.

Retina of Cebus fatuellus (*Brown Capuchin*). (Pl. II. fig. 3.)

The peripheral part of the retina begins from a smooth ora serrata, and almost immediately reaches a width of 119 μ. The ganglion cells are more numerous than in the Lemurs at the same point. Moreover, the cells are arranged in groups usually of three, and are not confined to the same plane. Some are placed nearer the internal limiting membrane and some are nearer the inner nuclear layer. The felt-work of non-medullated fibres is already considerable The inner molecular layer is much broader than the outer molecular layer, but the two nuclear layers are about the same dimensions. Each comprises nuclei of the same size and intensity of staining. The inner has four rows of nuclei: the outer has five.

The percipient layer is composed of both rods and cones. The cones are short and plump, and are placed at regular intervals among the rods. About four rods can be counted between the cones. The outer segments of the rods are short and about equal to the inner segments. There is a small amount of golden-brown pigment scattered amongst the outer segments of the rods.

In the middle area of the retina the width has increased to 170 μ. The inner limiting membrane is well marked. The ganglion cells form a single continuous row. Each lamina is well defined, and there are no outlying cells save for an occasional nucleus in the outer molecular layer. The two molecular layers are well defined; the inner is broader than the outer. The outer, however, is broader and better defined than the corresponding layer in the Lemurs. The inner nuclear layer comprises about five to six rows of cells, a slight increase on the more peripheral part. The outer nuclear layer is more compact and the stain is deeper, largely because the nuclei lie more closely together. There are six to seven rows of nuclei. The cone nuclei which occupy the outer part of the layer are not distinguishable from rod nuclei. The outer limiting membrane is not easily seen at this point, but the outer border of the nuclei is well defined. In

the percipient layer the cones are more numerous, and are separated from each other by the interposition of single rods. Both elements are much more elongate that in the peripheral part. The outer segment of the rod is now longer than the inner segment. The pigment is much less dense than in the nocturnal retina.

In the macular region the total thickness of the retina from the pigment layer to the internal limiting membrane is 272 μ. The chief distinguishing feature of the area is the enormous increase of the ganglion layer. Its nuclei now form a layer comparable in size to the inner and outer nuclear layers. The inner nuclear layer exceeds in thickness the outer nuclear layer. This is the reverse of what is the case in the Lemurs. In the rod retina the outer nuclear is far in excess of the inner nuclear layer. In the cone retinæ, where there is great advance in visual acuity, the outer nuclear layer is the small one, while the inner nuclear layer and the ganglion layer are enormously increased. This means an increase in visual efficiency by means of increase in the number of conducting elements. It seems to occur only when the rods are replaced by cones. In the percipient layer, rods are few and cones are abundant. Formerly the ganglion layer was a single row of cells. It has now become a layer six or seven cells thick. The inner nuclear layer is nearly double the width of the outer nuclear layer. The cells are more compact. The depth of the staining is the same in the two layers. There are about ten rows of nuclei in this layer. Its margins are sharply defined. The outer nuclear layer is extremely narrow and consists of about five layers of cells. The outer limiting membrane is now easily seen. An occasional nucleus lies amongst the rods and cones. In the percipient layer the cones predominate, but here and there between the cones a rod can be seen. The cones have become much more elongate—the long axis is about twice that of the cones in the peripheral part of the retina. The elements are quite regular and lie in contact with the pigment layer.

The fovea is situated in the centre of the macula, which extends for more than 1 mm. on each side. This occupies an area of about half a millimetre. The sections through the macula are disturbed by shrinkage which has caused a bending inwards of the retina. At the centre there is a fracture line. As the fovea is approached, the ganglion layer becomes reduced and forms a single line of cells. This disappears completely as the margin of the fovea is reached. The outer molecular layer ends at the margin of the fovea. The inner nuclear layer also becomes reduced as the cup is reached and its terminal cells, by the disappearance of the inner molecular layer, come into contact with the ganglion cells and then end. The percipient and the outer nuclear layers continue across the cup accompanied by a thin strip of the outer molecular layers and the internal limiting layer.

The percipient layer is composed only of cones. These have

very elongate bodies and short outer segments. They have in the fixation moved away from the choroid and pigment layer. These have (the choroid) a slight convexity outwards at the place of the fovea and this, no doubt, applied to the fovea itself when in its proper position before the fixation. Some pigment still attaches to the outer segment of the cone.

The Retina of Hapale jacchus.

The retina of the Marmoset has been described elsewhere (**14**). The following points are recapitulated. In the macula region the total thickness of the retina is 250 μ. The sensory epithelium consists of cones. The outer nuclear layer contains six rows of nuclei, the inner 15 rows, and the ganglion layer six rows. A fovea is present, but the inner nuclear layer passes more definitely across it than in the other specimens. The macula was seen and illustrated by Johnson (**7**).

The Retina of Macacus rhesus. (Pl. II. fig. 4.)

As soon as the retina begins to be regularly laminated in the region of the ora serrata, it exhibits the following features. The ganglion cells are separated by wide intervals. They may be single or grouped in pairs. They are disposed irregularly. The outer and inner nuclear layers are about equal in extent. The two limiting membranes are not easily seen. The inner nuclear layer consists of a double row of cells and its borders are irregular, for scattered nuclei are found in the adjacent molecular layers. The outer nuclear layer is more compact and consists of a triple row of cells. The sensory epithelium consists of both rods and cones. The cones are very short and broad. The retina measures in width 102 μ.

In the equatorial plane the limiting membranes are faint, but the lamination is well defined. The ganglion layer is a single row of cells closely packed together. The inner nuclear layer is loosely arranged and consists of five rows. The inner molecular layer is broader than the outer. The outer is bisected by a faintly stained line. The outer nuclear layer is very compactly arranged and the nuclei form six rows. Cones are extremely abundant. They are now much more elongate and the two segments are about equal. The thickness of the retina is about 204 μ.

The macular region shows a well-marked internal limiting membrane. The ganglion cells are three to four thick and very regularly arranged. The inner molecular layer is broader than the outer. The inner nuclear layer is much more extensive than the outer. Its outer border is a little irregular. There are nine rows of cells, and these are arranged in parallel fashion. The outer nuclear layer is very compact and consists of six rows of cells. The sensory epithelium comprises now very elongate cones whose outer segment exceeds the inner in length. There

is a slight amount of golden-brown pigment. The thickness of the macula is 236 μ.

The width of the fovea is 190 μ, and it is about five millimetres from the optic disc. Some swelling and wrinkling of the retina have occurred, so that the margins of the fovea pout inwards and the retina as a whole is shifted away from the choroid. The ganglion layer and the inner nuclear layer do not cross the fovea. The inner nuclear layer is continued across as a few scattered cells. The inner and outer limiting membranes are well marked. The cones have become very elongate. The distortion makes it impossible to determine precisely the original arrangement.

Cercocebus fuliginosus (Sooty Mangabey). (Pl. III. figs. 5, 5*a*.)

At the periphery the retina soon becomes well laminated. The ganglion cells are widely separated but regularly arranged. The inner molecular layer is narrower than the outer.

The inner nuclear layer is well defined and consists of a double row of cells. There are a few scattered nuclei in the outer molecular layer. The outer nuclear layer consists of a single row of cells. The sensory epithelium is made almost completely of cones. Rods are only occasional and have to be searched for. The staining of the rods and cones in this specimen is excellent. The thickness of the retina is 85 μ.

In the equatorial plane the internal limiting membrane is well marked. The ganglion cells are closely packed into a regular single row. The inner molecular layer is slightly broader than the outer. The inner nuclear layer consists of five rows of cells. The outer nuclear layer is the more compact and has the same number of cells. Cones are more abundant. No rods are found in this plane. The thickness of the retina is here 170 μ.

In the macular region the internal limiting membrane is well marked. The ganglion layer consists of eight rows of cells, but they are loosely arranged. The layer is 85 μ thick. The inner and outer molecular layers are equal. The inner nuclear layer comprises eight rows of cells. In this layer the outer row of cells is especially manifest, as it is slightly separated from the rest of the layer. The outer nuclear layer consists of only a double row of cells. The cones are all elongate, and the outer segment is equal to one-third of the inner segment. The retina is almost entirely composed of cones, only a few rods being found peripherally. The width of the retina is 250 μ.

The fovea is excellently stained and resembles most closely the human fovea as depicted by Golding Bird and Schafer (**5**). The obliquity of cones is slight. The inner nuclear layer shows about six nuclei scattered across the floor of the fovea. At the margins of the fovea there is an accumulation of nuclei in the outer nuclear layer which here becomes four cells thick.

Cercopithecus callitrichus (Green Cercopithecus).

This retina is poorly fixed. It however shows a macula and fovea. Rods are probably much more abundant than in the Sooty Mangabey.

The Retina of the Chimpanzee. (Pl. IV. fig. 6.)

The marginal area of the retina is connected with what appears to be a very extensive ora serrata. This is a true ora serrata in that it is not smooth as in the previous members of the primate series which we have studied. The inner lining appears to be in series with the inner nuclear layer. From the ora serrata each layer of the retina begins gradually, but soon reaches considerable dimensions. The internal limiting membrane is easily seen, and is continued from the ora serrata. The ganglion cells are a considerable distance apart. They are arranged in groups of two or three. A considerable interval separates the groups from one another. The network of non-medullated fibres appears abundant even right at the periphery of the retina. The inner nuclear layer begins as a single row of nuclei. This quickly becomes doubled. For some distance from the periphery there are numerous scattered nuclei in the outer molecular layer, but as one passes more towards the centre of the retina these scattered cells disappear and the margins of the nuclear layer become well defined. The group arrangement of the ganglion cells makes the inner molecular layer ill-defined. The outer molecular layer is narrow, and contains all through it groups of cells which belong to the inner nuclear layer. The outer nuclear layer is extremely compact and contains three rows of deeply-staining nuclei. These become obliquely arranged as the layer tapers towards the ora serrata. The external limiting layer is well defined, and at the periphery seems to be attached to the pigment layer. The percipient layer comprises both rods and cones. The arrangement and spacing of the cones and rods seems to be quite regular. Usually there would appear to be four rods between adjacent cones. Both elements are short. The pigment layer is so obscured by pigment that no details can be observed.

In the middle area of the retina each layer has become larger, more compact, and its limits better defined. The internal limiting membrane is well-defined. The ganglion layer is covered by a thin felt of non-medullated fibres. The individual cells are larger than those at the periphery, and they are close enough together to form a continuous layer. Here and there two cells may appear to be superimposed, and again adjacent cells may be separated by the interposition of blood-vessels. The outer margin of the ganglion layer is well-defined. The inner molecular layer has very well-defined borders. It is nearly twice as broad as the outer molecular layer. The inner nuclear layer consists of five rows of cells. The cells are of two types. The less numerous of these consist of small nuclei, circular or oval in shape, and so

densely staining that no details are visible. The second are more numerous, larger, ovoid in shape, with a well-defined nuclear membrane and a scanty chromatin network forming knots where the threads cross. The interstices are filled with a non-staining karyoplasm. This latter group resemble the nuclei that compose the outer nuclear layer. The outer molecular layer is narrow and composed of threads that surround circular spaces which appear transparent and empty. It is quite rare now for any nuclei to occupy this layer. The outer nuclear layer is sharply limited from the outer molecular layer, and the external limiting membrane, which is very sharp, separates it externally from the rods and cones. The nuclei appear very closely packed, and superimposition occurs in 10 μ sections.

The increase in the number of nuclei arises from the closer packing, and also in absolute dimensions it exceeds the width of the inner nuclear layer. There are seven rows of nuclei. They are circular or oval in shape, the nuclear membrane is well-defined, and the chromatin scanty. The nuclei are all of one type. The percipient elements are composed of both rods and cones whose inner segments rest on the external limiting membrane. The cones are more numerous than further peripherally, and are separated from each other only by one or two rods. The outer segments of the rods have the appearance of a series of discs.

The thickness of the retina in the equatorial plane is 175 μ.

Passing more centrally the nerve-fibre layer covering the ganglion cells grows more voluminous and the blood-vessels are more frequent and larger. Occasionally a large blood-vessel so far insinuates itself into the ganglion layer as to lie in the inner molecular layer and even indent the inner nuclear layer. Approaching the macula the ganglion layer increases. The single layer of cells first doubles and increases sharply until it forms six or seven rows of nuclei. The other layers show also an increase. The outer nuclear layer contains six or seven rows of nuclei. Rods and cones are both present in the outer layer of the retina.

In the macular region the total thickness of the retina has increased to 272 μ. The increase is most marked in the ganglion layer, which, instead of being a single layer, is now a mass of closely-packed cells forming six rows of nuclei. The gradient of the increase is sharp and takes place a short distance behind the equator of the eye. The inner molecular layer has increased, and the two types of nuclei in the middle portion of the retina, which were previously intermingled, have now segregated, so that the small densely-staining type forms three rows along the inner margin. There are in all about nine rows of nuclei, but they are more closely packed here than in the more peripheral parts of the retina. The outer molecular layer is narrow, and is segregated into two parts. The outer, subjacent to the outer nuclear layer, consists of a dense felt-work; the inner part appears looser and more transparent. Its inner margin seems to

form a laminated membrane with elongated thickenings, and sharply defines the outer border of the inner nuclear layer. Just as the inner nuclear layer has increased in volume, so the outer layer has decreased. It appears as if the inner part of this layer corresponding to the rod nuclei has disappeared. The nuclei have been reduced to three rows. In the percipient layer there are no rods. Cones somewhat elongate are alone present. This relation between the size of the nuclear layer of the percipient elements and the presence of rods and cones is constant in all the retinæ examined, and enables one to establish the composition of the receptive elements most readily. The cones are elongate, and the transverse diameter of the inner segment is reduced to 10 μ, whereas in the peripheral part it was 17 μ.

The fovea is about 0·5 mm. transversely. Its walls are prominent, owing to the accumulation of ganglion cells. These cease at the margin of the fovea. The inner molecular layer is absent from the foveal region. The inner nuclear layer crosses the fovea as a single layer of cells. The outer molecular passes over the excavation without any change in its dimensions. The cones are perpendicular in the foveal region, and their nuclear layer continues unchanged across the excavation.

The Retina of the Human Eye. (Pl. IV. figs. 7 & 8.)

The eye was divided equatorially, so that the most peripheral portion of the retina is not described. The middle portion of the retina presents the following features. The internal limiting membrane is extremely thick and prominent. The ganglion cells form a nearly continuous row. The inner molecular layer is broader than the outer. The inner nuclear layer comprises five rows of cells and is broader than the outer layer. Its outer margin is limited by a well-defined band. The outer molecular layer is well-defined, but not so broad as the inner molecular layer. The outer nuclear layer is somewhat irregular along its inner border, but the outer margin is limited sharply by a well-marked external limiting membrane. It comprises about four rows of cells, and is therefore smaller than the inner nuclear layer. The individual nuclei are smaller than those of the inner cell lamina. In the percipient layer the cones are extremely abundant. The rods appear as single elements between the cones. Both elements are short, and the inner and outer segments appear to be of equal dimensions. In the pigment layer there are scattered granules of golden-brown pigment. The total thickness of this part of the retina is 130 μ.

The macula has a total thickness of 197 μ. The internal limiting layer is well-defined. The ganglion cells form six to seven rows of nuclei. The outer nuclear layer is very well-defined. The inner nuclear layer is broad, compact, well stained, and consists of ten rows of cells. The outermost cells form a regular palisade, and are bounded by a clear granular band which is succeeded by the fibres of the outer molecular layer. The outer

molecular layer is well-defined, and presents adjacent to the inner nuclear the clear granular band just referred to. The outer nuclear layer is relatively narrow and consists of three to four rows of cells. The external limiting membrane is well-defined. The percipient layer is narrow and the cones are short. Only an occasional rod can be identified. The outer segment of the cone is about one-half the length of the inner portion. The pigment is moderate in amount.

The fovea has a diameter of about 0·66 mm. It begins as a shallow depression, at the margins of which the ganglion cells become a single row. Also the inner molecular layer is reduced to a narrow band. The inner nuclear layer is reduced to four rows of cells. The outer molecular layer retains its original size. The band originally described as granular has now become broadened, and assumes an alveolar pattern—*i.e.*, a network of clear spaces. The outer nuclear layer retains its original dimensions. The percipient layer consists entirely of cones. These are short and thick, and the two segments are about of equal dimensions. These cones are much thicker than in the Chimpanzee.

The fovea occupies the centre of an area whose diameter equals 316 μ. The internal limiting membrane is well-defined. Both the ganglion layer and the inner molecular layer disappear. Likewise the inner nuclear layer comes to an end. The outer molecular layer is continued across the depression. The cones and outer nuclear layer are arranged as in the macula. The whole depression is shallower than in the figures of other human retinæ. The retina as a whole is separated from the coats of the eyeball. There is no cupping inwards of these tunics as has been described. The formation of the alveolar pattern in the outer molecular layer may be some pathological change. This expansion reduces considerably the foveal depression.

Discussion.

It has already been mentioned that the retinæ of the more primitive specimens (*Tupaia* and the Prosimiæ) have not been previously microscopically studied. On the other hand, the Monkeys and Anthropoids have been studied a great deal, and the existence of the fovea and macula has been known since 1800. (Franz gives a list of nine specimens of the Simiidæ studied by Soemmerring.) In the present series the only discrepancy concerning the presence of a macula is the case of *Nyctipithecus*. It has not been found microscopically.

The specimens fall into two groups, the nocturnal and the diurnal retinæ. The nocturnal retina is characterised by heavy pigment, rods, an extremely abundant outer nuclear layer, a very much narrower inner nuclear layer, and a ganglion layer that is always single. Fovea and macula (except the peculiar arrangement in *Tarsius*) are absent. Here are included the Lemurs, *Tarsius* and *Nyctipithecus*. The diurnal retina is characterised

by cones, narrow outer nuclear layer, abundant inner nuclear layer, increase in ganglion cells, and the presence of macula and fovea. This group includes all the remaining specimens studied, except *Tupaia*, which conforms to the diurnal type but has no macula or fovea.

The following tables give the measure of the elements in the macular region of the retina of the specimens which possess macula and fovea. They are arranged in the order of visual acuity as assessed by the number of conducting segments, the degree of intermixture of rods and cones, and the extent and perfection of the fovea. The order is assessed entirely from the retina. No account is taken of what happens in the midbrain centres or in the cerebral cortex.

(1) *Cercocebus fuliginosus.*

Ganglion layer	8 rows.
Inner nuclear	8 ,,
Outer nuclear	2 ,,
Total width	250 μ

Fovea extremely regular and deep, and obstructing elements reduced to a minimum. Almost a pure cone retina. It was only at the periphery of the retina that occasional rods were found.

(2) *Chimpanzee.*

Ganglion layer	7 rows.
Inner nuclear	9 ,,
Outer nuclear	3 ,,
Total width	272 μ

There are rods in the macular region, and the excavation of the fovea is not so complete as the preceding. The measurements given by Hotta (6) show much variation in individual specimens of the Anthropoids. The measurements of the macula in the Chimpanzee range from 269 μ to 327 μ.

(3) *Man.*

Ganglion layer	6–7 rows.
Inner nuclear	10 ,,
Outer nuclear	3·4 ,,
Total width	197 μ

The macula and fovea are subject to much variation in Man (see the various illustrations (5)). The present specimen was probably not perfectly normal.

(4) *Cebus fatuellus.*

Ganglion layer	6 rows.
Inner nuclear	10 ,,
Outer nuclear	5 ,,
Total width	272 μ

The ganglion layer falls short of the preceding specimens.

(5) *Marmoset.*

Ganglion layer	6 rows.
Inner nuclear	15 ,,
Outer nuclear	6 ,,
Total width	250 μ

The excavation of the fovea is less perfect than in other specimens.

(6) *Macacus rhesus.*

Ganglion layer	4 rows.
Inner nuclear	9 ,,
Outer nuclear	6 ,,
Total width	236 μ

It is apparent that the measurements on which these tables are based show only a slender basis for such an order. The margin of error in the observations and the variations in specimens make any such order very insecure. It would be more prudent to say that the peripheral mechanism of vision is similarly differentiated in all Primates except the Prosimiæ and *Nyctipithecus.*

SUMMARY.

(1) The Lemuroidea examined are characterised by a retina of the nocturnal type.

(2) *Nyctipithecus*, a true Monkey, has a retina of the nocturual type without macula or fovea.

(3) The generalisation that a macula and fovea are found only in the retina when cones are present is confirmed.

(4) An additional distinction between the diurnal and nocturnal retina is present in the size of the nuclear layers. The outer nuclear layer is the larger in the nocturnal: the inner is the larger in the diurnal. Put another way there are more percipient elements than conducting elements in the nocturnal; the reverse is the case in the diurnal retina.

(5) An attempt has been made to arrange the Simiæ examined in the order of retinal differentiation. *Cercocebus fuliginosus* possesses the purest cone retina and the most perfect foveal excavation. The differences are too slight and the layers too individually variable to attach much validity to the above tables.

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EXPLANATION OF THE PLATES.

Plate I.

Fig. 1. Section through the central part of the retina of *Lemur*.

Fig. 2. Section through retina of *Nyctipithecus*, central part. Optic nerve visible on the left.

Plate II.

Fig. 3. Fovea and macula of *Cebus fatuellus* (Brown Capuchin).

Fig. 4. Retina, macula, and fovea of *Macacus rhesus*.

Plate III.

Fig. 5. Macula and fovea of *Cercocebus fuliginosus*.

Fig. 5*a*. High-power microphotograph of macula and wall of the fovea of *Cercocebus fuliginosus*.

Plate IV.

Fig. 6. Fovea and macula of Chimpanzee.

Fig. 7. Macula and margin of fovea in Man.

Fig. 8. Section through fovea of human eye.

2. Physical and Chemical Conditions in the Freshwater Circulation of the Zoological Society's Aquarium. By Flaxney Percival Stowell, B.Sc., Ph.D., A.I.C., Aquarium Research Fellow.

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Part I.

Physical Properties, Standards of Purity, and Small Variable Constituents.

In a previous paper read before the Society (Stowell, P. Z. S. 1925, p. 1241) the physical and chemical changes in the sea-water circulation of the Society's Aquarium were dealt with, and by means of comparison analyses with fresh sea-water from the original source of that in use in the Aquarium, the admirably effective results were rendered apparent of aeration, filtration, and storage on the maintenance of the Aquarium sea-water as a suitable medium for healthy fish and marine invertebrate life. The comparison, physical and chemical, was made possible on account of the fact that the Aquarium water had been submitted to the rigorous test of eighteen months' prolonged use without replenishment or replacement, and any cumulative change in the physical and chemical factors was rendered more apparent than if additions of fresh sea-water had been made periodically. An attempt to adopt the same line of attack for the freshwater circulation met with the difficulty that, although the main bulk of the water has been in circulation for the past two years, the source of fresh supply is much more accessible than that of the sea-water, and fresh supplies have been added from time to time to restore loss by evaporation. In consequence, an examination of the Aquarium fresh water and subsequent comparison with water from its original source had to be undertaken after a period had elapsed without the addition of fresh supply; and while the results obtainable do not give an absolute comparison since the inauguration of the Aquarium, they indicate the *trend* towards accumulation or depletion in any chemical factor and the change in physical environment during that time.

A remarkable parallelism is seen to exist between the sea- and fresh-water circulations with regard to purification effects and cumulative factors. The much smaller saline content of fresh water enables changes in concentration of the saline constituents to be detected much more readily, as these changes now lie outside the experimental error which is unavoidable in certain inorganic analyses, where a large original concentration of saline

constituent is involved. We refer to such ion constituents as calcium and magnesium. These will be discussed in Part II. of the paper. Nitrates, phosphates, and silicates exhibit the same behaviour as in the sea-water circulation, a decided increase being noticeable. The causes are discussed in the sections dealing with each. Such factors as turbidity, suspended matter, hydrogen ion concentration, ammonia and nitrate contents, which are assumed in water analysis as the standards of purity of a water, and which must also be maintained within narrow limits for the upkeep of healthy aquatic life, are all found, as in the case of the sea-water, to be practically invariable and well within the limits theoretically prescribed.

The methods of circulation in the freshwater section of the Aquarium are similar to those applying for the sea-water, with the exception that only one underground reservoir is available for storage. This is of 60,000 gallons capacity. The aeration is gravitational, and, as in the case of the sea-water circulation, may be reinforced if necessary by jets of compressed air entering the base of each show-tank. Filtration takes place through eighteen inches of sand. The conductance pipes differ from those employed in the sea-water section, being of galvanized iron instead of glass-lined.

Physical Properties.

A representative sample drawn from the circulation was colourless and odourless and free from turbidity. It contained a negligible amount of matter in suspension. The density at 12° C. was 1·0000, that of the source being 1·0000 at 9° C. The Aquarium fresh water is thus denser than its source, as we should expect if evaporation has taken place during its prolonged use.

Hydrogen Ion Concentration.

All p_H determinations were carried out as before by the colorimetric method. Attention was drawn in the paper on the sea-water circulation (*loc. cit.*) to the importance of the hydrogen ion concentration as an indication of the suitability of a medium for the maintenance of healthy life. The p_H may be termed an ultimate physical expression contributed to by a number of physical and chemical factors controlling acidity or alkalinity; and whereas it is not a complete criterion of the suitability or otherwise of a medium, it is nevertheless a quick and reliable indicator, and if outside certain limits, at once obviates the necessity of a more detailed examination.

London water is very hard, this hardness being due for the most part to the bicarbonates of calcium and magnesium. These particular salts are present in sea-water, and are the source of the so-called "buffer action" which the latter exerts to changes in free carbon-dioxide content and its consequent effect on

alteration of acidity. Hence the original source of the Aquarium water is a medium particularly suited to resist changes in p_H due to the production of carbon dioxide by the ordinary processes of fish metabolism. It will be remembered that the p_H gradient of the Aquarium sea-water between the reservoir and outflow from the tanks was only 0·07. This may be attributed to the buffer action of the bicarbonate content of the sea-water, which is kept remarkably constant by efficient aeration, which removes excess carbon dioxide.

The p_H of the Aquarium freshwater circulation at the point of inflow to the show-tanks was found to be 8·10 at 9° C., whilst that of its source was 7·75. The Aquarium water is thus slightly more alkaline than its source. Table I. gives the p_H of inflow and outflow from a representative number of the show-tanks :—

TABLE I.

Source of Sample.	Temperature.	p_H of water entering show-tank.	p_H of outflow.
Tank containing 5 bowfin .	12° C.	8·15	8·15
Tank containing 5 pike, 3 eels . . .	,,	8·15	8·15
Tank containing 50 perch .	,,	8·15	8·10
Tank containing 3 salamanders . . .	,,	8·15	8·15
Tank containing 12 goldfish	,,	8·15	8·15
Tank containing 10 carp, 10 golden orfe, and 6 tench .. .	,,	8·15	8·10
Tank containing 94 minnows .	,,	8·15	8·10
Tank containing 4 sterlet .	,,	8·15	8·15
Tank containing 20 sunfish ..	,,	8·15	8·15
Tank containing 10 trout .	,,	8·15	8·15
			Mean 8·13

It will be seen from the above table that the mean p_H of outflow is only 0·02 lower than that of entry. It would perhaps be more accurate to say that it is within 0·05 of that of entry, as the slight differences of colour of the indicator do not permit of a value of 0·02 p_H to be registered with certainty, and in all the readings recorded above, the value 8·10 or 8·15 was taken according as to whether the tint of the sample approached that registering either value.

The p_H gradient between inflow and outflow from the show-tanks is even less than that shown by the sea-water. This is

probably due to the fact that the freshwater show-tanks are not quite so heavily stocked as the sea-water. The results recorded for both, however, show that the system of aeration in use in both circulations is quite able to cope with the excess of carbon-dioxide production, due to the relatively large numbers of fish per unit volume. No attempt will be made in this paper to correlate p_H, alkaline reserve and carbon-dioxide content, as the relation deduced between these values for sea-water by McClenden and co-workers (Journ. Biol. Chem. xxx. p. 225, 1917, and Carnegie Inst. Wash. Dept. Marine Biol. xi. p. 23, 1917) cannot be applied with accuracy to the freshwater results. The alkaline reserve of the fresh water in terms of cubic centimetres of 0·01 N hydrochloric acid was determined however, and found to be of roughly the same magnitude as the value obtained for the sea-water in the Aquarium (25·25), viz. 29·7.

Estimation of Ammonia.

The origin of the ammonium salts in water has been discussed in a previous paper by the author (*loc. cit.*) on the sea-water circulation of the Aquarium. The method of estimation was essentially the same. Numerous determinations were made on tank, filter, and reservoir water and compared with the source of supply, and the average values for each are appended in the following table:—

TABLE II.

Source of Sample.	Free Ammonia in parts per 100,000 of water.	Albuminoid Ammonia in parts per 100,000 of water.
Supply	0·0041	0·015
Tank containing 50 perch	0·017	0·018
Tank containing 10 trout	0·019	0·019
Tank containing 20 sunfish	0·017	0·019
Tank containing 10 carp, 10 orfe, and 6 tench	0·019	0·020
Tank containing 5 pike, 3 eels	0·019	0·013
After filtration	0·0080	0·011
Reservoir (after mixing and approx. two days' storage)	0·0066	0·0095

The free ammonia values for the various show-tanks are remarkably constant, and are, as one would expect, higher than the source of supply. Filtration substantially reduces the value. As already mentioned, the presence of only one reservoir renders it impossible to store the water for a considerable period, as is customary with the sea-water, but each separate entity of water, as it were, is retained in the reservoir for approximately two

days before being pumped once more into the show-tanks—that is, the duration of storage is about two days. It is impossible during this short period to ascertain definitely any particular effect of storage, but it will be noticed that the effect of mixing and sedimentation has exerted a further reduction in the ammonia values.

Turning to the albuminoid ammonia values, these all approximate to the average value of 0·019 parts per 100,000. A notable exception is the tank containing pike, a fish which normally is sluggish and quiescent as compared with trout and other fast-moving fish, whose rate of metabolism one might expect to be higher. The highest value—0·020 parts per 100,000—is recorded for the large 4500-gallon tank containing large carp and golden orfe. Filtration is responsible for a large drop in the value, and mixing and storage a further reduction; in fact, the values for the filtered and stored water are lower than that of the supply.

Nitrites and Nitric Nitrogen.

Just as the albuminoid ammonia values in any water are an indication of the amount of soluble nitrogenous organic matter present, the presence of nitrites and nitrates indicates that oxidation of that organic matter is taking place. This organic matter is mostly of animal origin, as the efficient oxidation of vegetable organic matter is relatively much more difficult to bring about. Nitrite is the intermediate oxidation product, and is to be found where the oxidation is incomplete; but the presence of high concentrations of nitrate, especially if accompanied by chloride, is an indication of past sewage pollution which has been or is being efficiently oxidised. It will be remembered that in the case of the sea-water circulation (P.Z.S. 1925) normal ammonia values as compared with the open sea and high nitric nitrogen content indicated the efficiency of aeration and storage for suitable oxidation of the excess soluble nitrogenous organic matter to the harmless nitrate. We have seen in the previous section that the ammonia values are normal and strictly comparable with those of the supply. As the Aquarium water is certainly subject to sewage pollution by fish, the presence of high concentrations of nitric nitrogen will indicate that aeration is again responsible for efficient oxidation of soluble nitrogenous organic matter.

Nitrites were found to be present in the freshwater circulation of the Aquarium to the extent of less than one part in ten million of water, which is the minimal limiting amount detectable by the starch-iodide test. Their presence is consequently negligible. Nitrates existed in the concentration of 1·2 parts per 100,000 of water, or 0·012 grammes per litre. The source of supply contained 0·37 parts of nitric nitrogen per 100,000 of water, or 0·0037 grammes per litre. Nitrites were absent.

The results exhibit a close parallel with those observable in the sea-water circulation. The absence of nitrites indicates efficient

oxidation. The accumulation of nitrate is not so marked as in the sea-water, owing to the frequent addition of fresh supply with low nitrate content, but is sufficiently large to indicate the decided trend, and to prove the efficiency of aeration. Storage is not of prolonged duration; hence the oxidative processes must be ascribed to aeration and in smaller degree to filtration. The removal of nitrates cannot be effected owing to their great solubility, but, as in the sea-water circulation, their presence as such is harmless.

Phosphates.

In fresh waters, as well as in the open sea, the concentration of phosphate is variable, depending on the season of the year. Atkins (Journ. Marine Biol. Assoc. xiii. p. 119, 1923) has investigated the seasonal variation in this ion in both sea- and fresh-water. A steady decrease in surface phosphate was observed in the open sea during the spring, the value falling from 0·036 mgm. per litre in March to zero in July. This phenomenon is also noticeable in freshwater values by Atkins (*loc. cit.*) of the phosphate content of the water in the Maryfield Quarry Pond falling off from 0·042 mgm. per litre in November to zero in April of the following year. This is due, according to the author, to the uptake of phosphate by plankton during its growth in the spring and early summer months. The excretion of phosphate by fish and marine invertebrates serves to restore the balance. In an enclosed volume of water such as an aquarium, however, the phosphate produced by excretion by the relatively large numbers of fish is not balanced by the uptake by plankton. This must result in a decided increase in the concentration of phosphate in an aquarium circulation as compared with that in natural waters. This deduction is borne out by the fact that analyses by the author (P. Z. S. 1925, p. 1241) indicated the presence in the Aquarium sea-water circulation of 2·56 milligrammes of phosphate per litre of water as compared with 0·03 milligrammes in the open sea. A similar decided increase was recorded by Atkins (*loc. cit.*) for the sea-water in circulation in Plymouth Aquarium: viz. 5·0 milligrammes per litre. The lower figure for the Society's Aquarium was attributed to slight removal of phosphate by filtration after precipitation by iron salts in the water.

The method employed for the estimation of phosphate was that of Déniges (Compt. Rend. Soc. Biol. Paris, lxxxiv. p. 875, 1921). This is fully described in the paper on the sea-water circulation by the author (*loc. cit.*). The concentration of phosphate in the freshwater circulation (measured as P_2O_5) was 0·255 milligrammes per litre, while the supply contained 0·035 milligrammes per litre. Although these figures indicate that the concentration of phosphate in the Aquarium water is over seven times that in the source of supply, this increase is not nearly so marked as in the sea-water. This is due to the fact that frequent addition of fresh

supply containing the lower concentration of phosphates—0·035 mgm. per litre—prevents the same accumulation. The trend is sufficiently decided, however, to indicate the exact parallelism between the sea- and fresh-water circulations in the Aquarium.

Silicates.

It will be remembered that investigation on the Aquarium sea-water circulation revealed the fact that, in addition to increase in phosphate, the sea-water contained an abnormally large amount of silica in solution. This was accounted for by the fact that sea-water in contact with glass and cement exerts a solvent action on the latter, which contain large amounts of silica. The same phenomenon was observed by Atkins (Journ. Marine Biol. Assoc. xiii. p. 151, 1923), who found that silica passed into solution from glass bottles containing stored sea-water.

Determinations of the silica content of freshwater ponds and freshwater supplies by Atkins (*loc. cit.*) indicated a seasonal change which can be correlated with the seasonal growth of diatoms, since silica is an essential constituent of the valves of the latter. These seasonal variations probably account for the large variations in silicate values for various reservoir waters in the neighbourhood of London, the result of analysis depending largely on the time of the year at which the determination was undertaken.

The method of Dienert and Wandenbulcke (C. R. Acad. des Sciences, Paris, clxxvi. p. 1478, 1923) was again followed for the determinations of the silica content of the fresh water. The source of supply was found to contain 0·0045 grammes of silica as SiO_2 per litre of water in February of this year, while in the Aquarium freshwater circulation the concentration was 0·0055 grammes per litre. Values ranging from 0·124 grammes of silica per litre for Lambeth water to 0·007 grammes per litre for Staines water are quoted from the Metropolitan Water Board Reports to show that the silica content of the Aquarium water is normal and well within the average value for the district fresh-water supplies.

It was anticipated from certain results obtained regarding the saline constituents of the Aquarium fresh water, to be given in Part II. of this paper, that the silica content of the water would be considerably higher, owing to the passage into solution of silica from the rock-work and glass lining the freshwater circulation. This, however, is apparently not the case.

Objectionable Metallic Constituents.

Just as in sea-water, the ions of the heavy metals—lead, copper, zinc, manganese, and silver—are absent under normal conditions from fresh water; and their toxicity to freshwater fish-life is strictly comparable with that in sea-water. As stated in the

investigation on the sea-water circulation in the Aquarium, very little work has been done on the minimal concentration of these heavy metallic ions which are fatal to fish-life; and it is certain that the effect will be specific to the type of fish, and will also depend on the other conditions pertaining to the medium · for instance, fish living in well-aerated water will be much more resistant to the effects of contamination of that water by dangerous metallic constituents. The relative toxicity of any ion is also controlled by the suddenness to which the fish are exposed to its action; and whereas a sudden injection into the medium of a certain concentration of that ion might cause distress and even fatal results, a continuous and constant exposure to slightly increasing concentrations over a period of months regulates the adaptability of the life in that medium to the new condition, which might have fatal results to anything freshly introduced. Obviously, however, it is wise whenever possible to eliminate any danger whatsoever by ensuring the absence of dangerous metallic constituents. It was with this object in view that the absence was insisted upon in the Aquarium circulations, both salt and fresh, whenever possible, of fittings of dangerous metals. If the use of such was absolutely indispensable, precautions have been taken to prevent solution taking place by protective coatings.

As a consequence, the freshwater circulation contains no lead, copper, manganese, silver, or tin. Iron, though present in large quantities as precipitated rust in various bypasses of the circulation, is only present in minute quantities *in solution*. The main circulatory pipes in the freshwater section are of galvanized iron, and consequently the water contains small quantities of zinc. The concentration, however, is of the order of one part in 1,000,000 of water, which may safely be judged to be quite harmless. In fact, the continued healthiness of the fish is sufficient proof of the point!

Discussion.

As already stated, the above analysis includes only an estimation of the so called standards of purity of a water and the relatively small and variable constituents such as phosphate and silica, as compared with the invariable constituents which make up the solid content of any water. The latter will be discussed in Part II. of this paper.

The results quoted above indicate the exact parallelism which exists between the fresh- and sea-water circulations of the Society's Aquarium, and are a striking proof of the efficiency of the existing methods of physical and chemical purification of the water. In Nature, the delicate balance of oxygen and carbon-dioxide tension, which is expressed analytically by the p_H or hydrogen ion concentration, is maintained in fresh-, as in sea-water, by the restoring and corrective influence of photosynthesis of plant-life, on the tendency to increase of carbon-dioxide content and consequent acidity produced by animal-life. In the

spring and early summer months the multiplication of vegetable plankton and large abstraction of carbon dioxide causes a rise in p_H, or tendency to alkalinity, which drops as winter approaches. On the other hand, the concentration of phosphates, which are produced by fish metabolism, decreases during spring and rises in winter. The variation in silica content is more complicated, being connected, according to Atkins (*loc. cit.*), with rainfall and temperature, which favours solution of silicates The removal of silica by diatoms causes a decrease in spring, owing to the multiplication of the latter.

In an artificial enclosed volume of water such as an aquarium, the corrective influence of photosynthesis by plant-life is by no means strong enough to cope with the excess carbon dioxide produced by the crowded fish-life in the medium, for, although algal life is in evidence in the Aquarium, it is relatively scanty. As a consequence, artificial means must be sought to remove excess carbon dioxide and supply the oxygen necessary for the maintenance of a normal medium. It has already been stated that an alteration in the oxygen-carbon dioxide equilibrium of a water is, *ceteris paribus*, manifested by a change in the p_H, and, conversely, a water which exhibits a constant p_H is maintaining a constant oxygen-carbon dioxide ratio. Examination of the p_H values in Table I. affords a sufficient proof that the latter ratio is constant even in show-tanks crowded with fish, the p_H gradient between inflow and outflow being only 0·05 in the most extreme cases. The p_H of the Aquarium water in bulk also had not differed from its source of supply by more than 0·4 after months of use; in fact, it was slightly more alkaline than its source, indicating less carbon-dioxide content. In the absence of aeration, the carbon-dioxide accumulation would almost invariably manifest itself in the increasing acidity of the water; but the passage through the water of minute bubbles of air containing carbon dioxide at atmospherical partial pressure is continually removing the excess produced by fish metabolism.

Turning to the albuminoid ammonia values, we find that the average value for the bulk of the freshwater circulation is practically identical with the value for the source of supply. As expected, the values for the show-tanks are higher than for the other parts of the circulation. The value of filtration and storage is at once apparent on an examination of the results, each causing a progressive lowering in concentration of soluble nitrogenous organic matter.

In the values recorded for nitrite and nitric nitrogen, the exact parallelism between fresh- and sea-water is again observable. To the action of nitrate-forming bacteria, and in a much larger degree to the action of the aeration, may be ascribed the formation of nitrate from the soluble nitrogenous organic matter. This harmless oxidation product has accumulated, being soluble and consequently not removable by filtration. The absence of

nitrite is recorded, as in the sea-water circulation, and is a further proof of the completeness of the oxidative processes.

The accumulation of phosphate must be ascribed to the same causes as the increase in the sea-water circulation, the removal of phosphate by algal plankton not being nearly large enough to balance that added through excrement by the relatively crowded fish-life. Though filtration causes a slight removal, aeration has no effect.

The following table is included in order to afford at a glance the parallelism in behaviour between the sea- and fresh-water circulations:—

TABLE III.

Representative factor or Constituent Ion.	Aquarium Water.	Open Sea.	Aquarium Fresh Water.	Source of Supply.
p_H	7·78 (mean)	8·10	8·13	7·75
Free Ammonia in parts per 100,000	0·008	0·012	0·007	0·004
Albuminoid Ammonia in parts per 100,000.	0·017	0·017	0·010	0·015
Nitrites	—	—	—	—
Nitrates in parts per 100,000	5·1	0·073	1·2	0·37
Phosphate as P_2O_5 in mgm. per litre	2·56	0·03	0·255	0·035
Silica in mgm. per litre	4·0	0·2	5·5	4·5

The relative constancy in p_H, free and albuminoid ammonia is well indicated in each case, whereas the accumulation of nitrate, phosphate, and silicate in both fresh- and sea-water during their use is apparent. The rise is not so marked in the case of the fresh water, due, as already stated, to the frequent addition of fresh supply with low content of these ions. The trend, however, is clearly shown. We find, however, that the silica content of the Aquarium fresh water is relatively very little greater than that of its source, the rise in concentration being not nearly so marked as in the sea-water. Fresh waters contain much more silica in solution than pure sea-water, and consequently, having more nearly reached the saturation point, have a smaller solvent action for silica.

Summarising the results in conclusion, two main facts are apparent—the physical and chemical purity of the water after months of continuous use; and the parallelism which exists between fresh- and sea-water circulations with regard to accumulation of nitrate, phosphate, and silica.

Part II.

Non-Volatile Saline Constituents.

In Part I. of this paper, which dealt with estimations of the so-called standards of purity of a water and of constituents which in natural waters are seasonable and variable, a remarkable parallelism was pointed out between the behaviour of the fresh- and sea-water circulations with regard to the variation of the above factors when compared with respective sources of supply. With regard to the actual saline constituents, however, a comparison cannot be drawn. In the first place, the concentrations of the separate saline constituents in sea-water are very large compared with any changes (apart from simple concentration by evaporation) which are likely to have occurred, and consequently such changes probably lie within the unavoidable experimental errors of inorganic analysis. As a result very small changes in any saline constituent were not detectable, and a comparison with the fresh water is not available. Owing, however, to the much smaller saline content of the fresh water and its source of supply, the changes in the concentration of any ion constituent comprising the whole now lie well outside the experimental error, and small variations in any constituent are easily detectable. As stated in Part I. of the paper, it is not possible to estimate the *absolute* increase in concentration in any constituent since the circulation was first put into operation, as fresh supplies of water have been added at frequent intervals to make up loss by evaporation. Though these additions successively alter the absolute concentration of the saline matter in solution, it is possible by analyses to determine the *trend* of any chemical factor towards accumulation or depletion.

The methods of analysis, with the exception of those employed for calcium and magnesium, are similar to those employed by the author for the estimation of these constituents in the sea-water circulation (Stowell, P. Z. S. London, 1925, p. 1241), and are not given in detail.

Total Dissolved Solids.

The estimation of the total dissolved solids was carried out at 180° C. One litre of the Aquarium water contained 0·4745 gms. of saline matter as the mean of four determinations, while the concentration of total dissolved solid in the source of supply of the fresh water was 0·3033 grammes per litre. This represents an increase of total dissolved solid in the Aquarium water of over 50 per cent. This increase may be attributed to various factors. Continuous evaporation of the solvent increases the concentration of the non-volatile saline matter. The addition of fresh supply containing 0·3033 grammes of solid matter per litre makes up to the original bulk of water, but naturally adds a certain amount of saline matter, viz. 0·3033 grammes per litre of supply added.

Further evaporation of solvent concentrates the solid matter again, and so on, the net result being a considerable increase in total dissolved solid, as shown by the above figures. Another factor which may contribute to the increase of solid is any separate large increase of any one constituent ion comprising part of the total solids. If all the constituents making up the total dissolved solid matter have increased in concentration by over 50 per cent., it may safely be concluded that simple evaporation of solvent is the only factor bringing about the increase in total solid. But if any one ion constituent has increased disproportionately, the reason for that increase must be found. As already mentioned. the relatively small concentration of saline matter in fresh water as compared with sea-water (35·5 grammes per litre) renders such increases in concentration of each ion constituent easily detectable by the ordinary methods of inorganic analysis.

The increase in total solid matter is no cause for alarm, as the density of the water is only increased by 0·15 per cent., a condition to which any fish or invertebrates automatically adapt themselves without any trouble.

Chlorides.

The chloride ion present in water is usually in combination with sodium, calcium, and magnesium. It may be derived from various sources. Practically all soils and rocks contain chlorides; hence all waters contain traces of this element. Tidal rivers derive their chlorides from their proximity to ocean waters. Sewage and urinary matter also contain chlorides, so that any water subject to sewage pollution must hold combined chlorine in solution. This is associated in sewage with soluble nitrogenous organic matter. In the case of efficient sewage purification by oxidation processes, the latter is converted to nitrate, the chloride remaining as the indication of the now harmless contamination. Hence the estimation of chloride and nitrate serves as a useful guide, the simultaneous presence of these inorganic ions *in excess* being an almost certain index of past sewage contamination. If, however, the ammonia values are normal and the nitrate high, an equally sure indication is afforded that that sewage pollution has been and is being efficiently oxidised, and consequently rendered harmless.

The chloride in the samples submitted was estimated with standard silver nitrate solution. The original source of the Aquarium water was found to contain 0·018 grammes of chlorine as chloride per litre, agreeing well with the values cited by the Metropolitan Water Board for the chloride content of various of their supply reservoir waters. The mean of several chloride determinations of representative samples from various points of the Aquarium circulation yielded the value of 0·116 grammes per litre. The concentration of chloride ion in the Aquarium water is consequently six times that in the original source. This excess

of combined chlorine may be due to various causes. A small amount is due to the inevitable addition to the water of the soluble products of fish metabolism, the harmful constituents of which are oxidised to nitrate, leaving the chloride in excess. The close proximity of the sea-water and continuous deposition of minute traces of chloride from the air and accidental contamination with small amounts of sea-water might conceivably add to the chloride content. It cannot be solely attributed to progressive accumulation by evaporation of solvent, as the maximum increase possible from the increase in total solid is 50 per cent., on the assumption that the latter is caused by simple evaporation.

Sulphates.

The sulphate ion was estimated gravimetrically by precipitation from boiling solution by barium chloride in samples of Aquarium water and its source of supply. The former contained in four representative analyses 0·0498, 0·0500, 0·0498, and 0·0496 gms. of sulphate respectively, while the source of supply yielded the values 0·0408, 0·0409, and 0·0408. The percentage increase in concentration is thus 22. This increase is not so marked as in the case of the chloride content, and is most probably due to a large extent to the progressive evaporation of solvent. Fish excrement also contains small amounts of sulphate, obtained in the first place from their food as free or combined sulphur.

Calcium and Magnesium.

The amounts of calcium and magnesium present in an ordinary potable water are relatively exceedingly small, but vary considerably in samples from different districts. They exist in combination with bicarbonates, sulphates, and chlorides, and are important, as they are responsible for the hardness or the soap-destroying power of a water ordinarily for domestic use. For our present purpose they are also extremely important, as the buffer action of a fresh water (as of sea-water) to changes in acidity through increase in carbon-dioxide content is due to the presence of bicarbonates, which, as already stated, are in combination with calcium and magnesium. To the bicarbonates of calcium and magnesium is attributed the temporary hardness of a water; to the sulphates and chlorides of these metals, and the small amount of carbonate which is soluble, the permanent hardness. The former may be removed by boiling, as this removes carbon dioxide and precipitates the carbonates of calcium and magnesium, which are more or less insoluble. It has already been stated in Part I. of this paper that the presence of the bicarbonates of calcium and magnesium in relatively large amounts in London water render it peculiarly suited to maintain a fairly constant p_H when subjected to the test of forming a medium for the support of crowded fish-life, as in an aquarium. The alkaline reserve of the Aquarium fresh water has been cited as equivalent to 29·7 c.c.

of 0·01 N acid. This figure is confirmed by the value for the hardness of the water, which is 19. The London tap-water which is the source of supply has an alkaline reserve of 28·9 and hardness 16. The increase in alkaline reserve and hardness values indicate that carbonates and bicarbonates of calcium and magnesium have increased slightly.

Although the determination of the hardness of a water is the basis of a rough calculation of the amount of calcium present, sufficient in many cases for an ordinary routine analysis, the concentrations of calcium and magnesium ions must be determined, if needed, by the more exact gravimetric methods of inorganic analysis. The accurate estimation of small amounts of these ions needs great care in experimental manipulation, as there is a tendency for magnesium to become occluded in the calcium precipitate on their separation. This renders the value obtained for calcium too high and that for magnesium too low. Numerous modifications and small improvements were made in the present method of separation and estimation, until the results were reproducible in the case of calcium to 0·7 per cent. and in the case of magnesium to 1 per cent. in a total weight of 0·1 grammes per litre of water, or 1 part in 10,000. The method was based upon the fact that magnesium is not occluded to any appreciable extent in the calcium precipitate in the presence of organic salts, and that the second precipitation of the calcium after careful washing and dissolving in hot dilute hydrochloric acid finally frees it from any remaining magnesium.

A known volume of the sample, 500 cubic centimetres, was concentrated to a small bulk by evaporation after acidification with a few drops of hydrochloric acid. It was then rendered alkaline, a small amount of sodium acetate or ammonium citrate added, and the calcium precipitated from boiling solution in the presence of ammonium chloride by finely-powdered ammonium oxalate. The precipitate is rendered granular by the above precautions, and settles rapidly. The precipitate was washed on the filter with hot water, the filtrate containing the magnesium. The precipitate was next dissolved in a few drops of dilute hydrochloric acid and washed through with hot water. The calcium was re-precipitated with ammonium hydroxide and a few drops of ammonium oxalate solution, and again filtered and washed with distilled water till the washings gave no turbidity with silver nitrate solution. The washings were added to the original filtrate. The precipitate was dried, ignited at a dull red heat, and weighed as calcium carbonate. A few drops of strong ammonium-carbonate solution were added to convert any calcium oxide formed during ignition to calcium carbonate, the precipitate dried, heated once more, and re-weighed. This process was repeated till the weight of calcium carbonate was constant From this value the calcium ion was calculated as usual.

The filtrate, which contains the magnesium, was evaporated to dryness and ignited to char off organic matter and ammonium

salts. The residue was re-dissolved in water containing a little hydrochloric acid and filtered. The solution was heated to boiling, and microcosmic salt solution added drop by drop until precipitation was complete. The greater part of the magnesium was now in the form of $MgHPO_4$. The solution was allowed to cool, and one-third the volume of 0·880 ammonium-hydroxide solution added with constant stirring. The amorphous precipitate was at once changed into crystalline $MgNH_4PO_4 \cdot 6H_2O$, and any magnesium still remaining in solution thrown down in the same form. By this method the formation of $Mg_3P_2O_8$ was prevented. The precipitate was filtered, washed free from soluble phosphates, dried, ignited, and weighed as pyrophosphate.

The concentration of calcium and magnesium ions in the Aquarium freshwater circulation were 0·0960 grammes per litre and 0·0280 grammes per litre respectively. In the supply the values were 0·0860 and 0·0090 grammes. The percentage increase in calcium ion is nearly 12, while the concentration of the magnesium ion has risen 329 per cent. This accumulation cannot be accounted for by simple concentration through evaporation. Consequently the presence of these ions in relatively excessive amount is of great interest chemically.

The Alkali Metals.

Most fresh waters contain sodium, but very few contain enough potassium to render the determination of the latter worth while, as its significance in this minute amount is totally negligible. The qualitative flame test for potassium was very evanescent; hence a quantitative determination was not undertaken, especially as analyses of water supplying the London district made by the Metropolitan Water Board (see Metropolitan Water Board Reports) do not include potassium as an appreciable saline constituent. The method of estimation of the sodium was exactly similar to that described in the sea-water analysis (*loc. cit.*). The concentration of sodium ion in the Aquarium water was 0·0402 grammes per litre, and in the source of supply 0·0173 grammes per litre. This again represents an increase, this time of 132 per cent.

Carbonates.

The carbonate present in 200 cubic centimetres of each water was estimated by titration with standard hydrochloric acid, using a very delicate solution of methyl orange as indicator, and taking the usual precautions against excess of atmospheric carbon dioxide. The estimation requires great care in the determination of the end-point, and the results represent the mean of a large number of estimations. The Aquarium water was found to contain 0·1270 grammes of carbonate ion per litre, while the source contained 0·1240 grammes per litre. This does not

represent a very large increase in concentration, but, in any case, the total carbonate ion in any water is variable.

Nitrate and Silicate.

Although these ions are discussed in Part I. of this paper as variables when compared with the more or less constant saline constituents of a normal natural water, which are not directly called into play in the metabolism of fish-life, they must be ranked as non-volatile inorganic ions, and as such form constituents of the total solid matter estimated in this analysis. Hence their concentrations must be included in the table of results, as they are necessarily in combination with metallic cations. The concentrations of nitrate and silicate in the Aquarium water were respectively 0·0120 grammes and 0·0055 grammes per litre, while in the source of supply they were 0·0037 grammes and 0·0045 grammes respectively. The causes of increase in concentration of the nitrate ion are explained in Part I. as being the final oxidation product of soluble nitrogenous organic matter, and being very soluble, must accumulate. The concentration of silicate is high, though not very far removed from normal.

Discussion of Results and Investigation of the Causes of Abnormality.

From Table I. may be seen at a glance the concentration of each constituent saline ion in the Aquarium water and in its source of supply. Analyses are also appended from the Metropolitan Water Board Reports of Lambeth and Staines waters, by way of comparison.

TABLE I.

Constituent Ion in gms. per litre.	Aquarium Circulation.	Source of Supply.	Lambeth Water.	Staines Water.
Calcium	0·0960	0·0860	0·0967	0·0920
Magnesium	0·0280	0·0090	0·0092	0·0092
Sodium	0·0402	0·0173	0·0129	0·0113
Chloride	0·1160	0·0180	0·0177	0·0164
Sulphate	0·0498	0·0408	0·0458	0·0425
Silicate	0·0055	0·0045	0·0124	0·0074
Carbonate	0·1270	0·1240	0·1286	0·1226
Nitrate	0·0120	0·0037	0·0027	0·0019
Total dissolved solids..	0·4745	0·3033	0·3260	0·3033

It will be seen from the above results that the saline constituents of the source of supply are all directly comparable with those in the tables of analyses of Lambeth and Staines waters.

Turning to the Aquarium fresh water, the values for magnesium, sodium, chloride, and sulphur ions are abnormally high. In order to show that these increases in concentration are not due to the simple physical process of evaporation, the following table is appended, showing the necessary concentration of each constituent in the Aquarium water if simple concentration of the total saline matter from 0·3033 grammes per litre to 0·4745 grammes per litre had taken place:—

TABLE II.

Constituent.	Aquarium Water (actual concentrations).	Figure obtainable if total saline matter were concentrated by evaporation.
Calcium	0·0960	0·1346
Magnesium	0·0280	0·0141
Sodium	0·0402	0·0271
Chloride	0·1160	0·0282
Sulphate	0·0498	0·0639
Silicate	0·0055	0·0071
Nitrate	0·0120	0·0058
Carbonate	0·1270	0·1941

Obviously the concentrations of the ions of magnesium, sodium, chloride, and nitrate are abnormally high in the Aquarium freshwater circulation; in fact, the highness in the values prevents any rough proportionality being drawn between the remaining figures.

Although the presence in excess of these ions in the circulation is of no danger to fish-life, it is nevertheless of interest chemically to investigate the reason of their accumulation. The simultaneous presence in excess of sodium and chloride ions, together with magnesium ion, suggests the infiltration of a small trace of sea-water. Very little sea-water indeed, with its concentration of sodium chloride of 18 grammes per litre, would be necessary to raise the concentration of sodium and chloride ions to the extent shown above. The close proximity in the Aquarium of the fresh- and sea-water reservoirs, which are separated only by a concrete wall, suggests a possibility of a slight admixture by diffusion through the walls of the reservoirs. On this assumption it is possible to calculate, say, from the increase in chloride ion in the Aquarium freshwater circulation, and knowing the chloride ion content of sea-water, the amount of sea-water which would be necessary to bring about that increase, and the corresponding expected increase in the other constituent ions if brought up to that figure. Calculations based on such an assumption are given in Table III.

TABLE III.

Comparison between the Concentrations of the Constituent Ions in the Aquarium Water and the Concentrations expected on the Basis of Admixture with sufficient Sea-water to raise the Chloride Content to 0·1160 grammes per litre.

Constituent Ion in grammes per litre.	Source of Supply.	Source of Supply on assumed admixture with Sea-water.	Actual value in Aquarium Circulation.
Calcium	0·0860	0·0881	0·0960
Magnesium	0·0090	0·0161	0·0280
Sodium	0·0173	0·0706	0·0402
Chloride	0·0180	0·1160	0·1160
Sulphate	0·0408	0·0542	0·0498
*Silicate	0·0045	0·0045	0·0055
†Nitrate	0·0037	0·0039	0·0120
Carbonate	0·1240	0·1320	0·1270
	0·3033	0·4851	0·4745

* The sea-water circulation then contained 0·01 gm./litre NO_3.

† The sea-water circulation then contained 0·002 gm./litre silicate.

It will be seen that calculations on the basis of such an admixture with sea-water will not quantitatively account for the accumulation of certain ions. Calcium, magnesium, silicate, and nitrate ions are present in the freshwater circulation in greater quantity than admixture would account for completely, while sodium, sulphate, and carbonate ions are low in value. Hence, although it is possible that very small quantities of sea-water may have admixed with the fresh water by diffusion through the walls of the containing reservoirs, another explanation must be sought for the increase in calcium, magnesium, silicate, and nitrate ions. The cause of the accumulation of nitrate ion is known, and has been accounted for already. The abnormal increase in the other ions must be sought for in the passage into solution of minute amounts of such material as rock-work and cement, which line the show-tanks and other parts of the circulation. Various kinds of rock were employed in the construction of the show-tanks, including granite rock from Cornwall, Leicestershire and Derbyshire, Greensand Stone from Wiltshire and Derbyshire, and Limestones from Yorkshire and Westmorland.

The percentage composition of typical granites, limestones, and sandstones are here given. The figures are taken from the Geological Survey:—

	Dartmoor Granite.	Leicester Granite.	Derby Sandstone.	York Limestone.
Silica	71·60	67·16	98·45	0·12
Aluminium oxide	14·03	16·20	0·03	0·02
Iron "	0·57	3·82	—	0·13
Magnesium "	0·66	1·58	0·22	0·10
Sodium "	3·03	2·43	...	...
Calcium "	1·49	2·59	0·33	55·50
Potassium "	4·59	5·38	...	...
Carbonate	...	..	...	43·80
Water	..	...	0·85	0·04

A Derbyshire Limestone:—

Silica	3·6
Oxides of iron and aluminium.	1·8
Magnesium carbonate	40·2
Calcium carbonate	51·1
Water	3·3
	100·0

A Wiltshire "Greensand":—

Oxides of iron and aluminium	1·20
Calcium carbonate	94·52
Magnesium carbonate	2·50
Water	1·78
	100·00

It was not likely that the harder granites would be affected much by the solvent action of the water, but the softer lime and sandstone are more liable to attack. A particularly soft Derby limestone was chosen, which lines several of the freshwater show-tanks, and submitted to the action of a sample of the fresh water from the source of supply, in order to ascertain if any solvent action took place. A known volume of the water (250 cubic centimetres) was boiled for one hour with a sample of the rock, the solution filtered, and the calcium, magnesium, and silicate ion content of the filtrate analysed after the experiment. A blank test was undertaken at the same time with an equal volume of the test-water to serve as a control, as boiling precipitates a certain amount of calcium and magnesium as carbonates, and dissolves silica in suspension. The results are given below:—

Constituent Ion in Grammes per Litre.	Sample after boiling with rock.	Control.
Calcium	0·0267	0·0205
Magnesium	0·0108	0·0061
Silicate	0·100	0·085 *

* High value due to passage of suspended silica into solution on boiling.

The figures quoted show an appreciable solution of calcium, magnesium, and silica from the rock sample.

Samples of granite rock did not dissolve appreciably when submitted to the same test. A sample of Wiltshire Greensand stone, however, treated in the same way, showed the passage into solution of calcium ion. Sufficient evidence has been given to show that the abnormal concentration of calcium, magnesium, and silica in the Aquarium circulation is due to slight solution of rock work lining the tanks.

The increase in chloride content is due to two causes. The first is given in Part 1. of this paper. The simultaneous presence in the circulation of the ions of chloride and nitrate in abnormal concentrations points to past sewage pollution which has been efficiently oxidised. The soluble products of fish excrement contain chloride and soluble nitrogenous organic matter. The latter has been oxidised into nitrate ion, leaving the chloride unchanged, the net result being the simultaneous presence of nitrate and chloride ions in high concentration. The second cause may be taken in conjunction with the high sodium content as accidental and practically unavoidable admixture with sea-water, due to the close proximity of the fresh- and sea-water reservoirs, causing, in the opinion of the author, a diffusion of very small amounts of sea salts through the concrete walls of the adjoining underground reservoirs. These walls are lined with an impervious material, but slight cracks in the lining will permit of diffusion, through the difference in osmotic pressure which tends to be set up between the two solutions. The diffusion and admixture, it must be remembered, has been very slight for such a relatively small increase in saline content.

In addition to the abnormal concentration of any particular ion, a regular concentration of each constituent has taken place by simple evaporation of pure solvent and the addition of fresh supply already containing a small amount of saline matter. As already stated, while of interest from a physical and chemical point of view, the presence of relatively high concentrations of these non-volatile ions is no cause for alarm, as none of them are harmful to fish-life until a considerably higher concentration is reached. The estimation of the physical and chemical standards of purity in Part I. of this paper indicates the good condition of the fresh water in the Aquarium, and the complete absence of any of the toxic heavy metal ions and other harmful constituents.

Summary.

1. A physical and chemical investigation of the freshwater circulation in the Society's Aquarium has been carried out, including an estimation of the standards of purity, and small constituents such as phosphate and silica, which in natural waters are seasonable and variable.

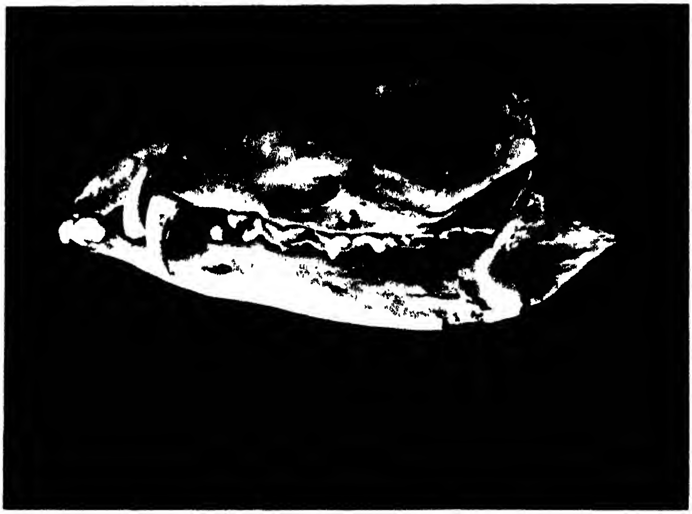
2. An analysis of the non-volatile saline constituents has also been undertaken.

3. From the point of view of the standards of purity, the results reveal the normality of the water and its continued suitability as a healthy medium for fish-life.

4. Comparison with the same factors in the course of supply indicate an exact parallelism with the sea-water circulation in trends toward accumulation or depletion of constituents, and the similar effects of the various methods of purification employed in both circulations.

5. A general concentration has taken place in the non-volatile saline constituents, due to evaporation, with an abnormal increase in the concentrations of certain ions. This has been found to be due to solution of rock-work lining the show-tanks, slight and unavoidable admixture with sea-water through diffusion in the containing reservoirs, and harmless oxidation products of fish-sewage metabolism.

6. Dangerous metallic constituents were absent.



CHROTOGALE OWSTONI.

CHROTOGALE OWSTONI.

3. The Delacour Exploration of French Indo-China—Mammals. By Oldfield Thomas, F.R.S., F.Z.S.

[Received October 1, 1926: Read February 8, 1927.]

(Plates I., II.)

In the course of last winter, by the kind co-operation of the Trustees of the Percy Sladen and Godman Exploration Funds, Mr. Willoughby Lowe was enabled to assist the well-known ornithologist M. Jean Delacour, F.Z.S., in the latter's exploration of French Indo-China, by which the scientific knowledge of the zoology of that little-known country has been so much advanced.

Owing to Mr. Delacour's local knowledge, and the help given by the French Government authorities, the expedition was conducted under the most favourable conditions possible, and a very fine collection was obtained, of which by Mr. Delacour's kindness I have been privileged to give an account, so far as the mammals are concerned.

The collection consists of about 400 specimens, belonging to no less than 72 species and subspecies, a number very rarely attained by any collector, even in Africa, and one showing the extreme richness of the fauna. Eight forms have proved to need description as new.

It will be remembered that in the winter of 1923–24 Mr. Herbert Stevens, also by the help of the Godman and Percy Sladen Trustees, made in Tonkin for our National Museum a collection of Mammals of which I gave an account in the Society's 'Proceedings' *. That, however, was merely a first step towards a knowledge of the mammalogy of French Indo-China, a subject in which the work of Messrs. Delacour and Lowe marks a further stage, all the more important that the region explored was so very different from that visited by Mr. Stevens. For the latter worked solely in Tonkin, in the north of the general area, while the present exploration was conducted in well-selected localities in Annam and Laos, the two collections thus supplementing each other in giving a preliminary basis for the further close survey of Indo-China which Mr. Delacour hopes to carry out in the future.

The localities worked by Messrs. Delacour and Lowe were as follows—the two first being those at which the largest collections were made:—

Xieng Khouang (variously spelt Kien or Xien Quang or Kuang) in the centre of Northern Laos, about 19° N., 103° E., at an altitude of about 4000 feet.

* P. Z. S. 1925, p. 495.

Col des Nuages *, Central Annam, behind Hué and Tourane, in the hills about 100 km. from the east coast. Altitude 1200 feet.

Hué itself, the capital of Annam. 16° 24′ N., 107° 32′ E. Sea-level.

Dak-to. south of Hué again, about 100 km. from the coast and about 14° 30′ N., 108° 0′ E. Altitude 3000 feet.

Kontoum, still further south on the same plateau. 14° 0′ N., 108° 0′ E. Altitude 3000 feet.

Of the mammals collected by Messrs. Delacour and Lowe the most important is the adult specimen of the remarkable Carnivore *Chrotogale owstoni*, of which I am at last able to describe the permanent dentition, although even yet a complete adult skull has not been obtained. Two new species of the striking genus *Hapalomys*, hitherto monotypic, have also been discovered.

The first set of the Mammals, including the types, is allowed to be retained by the British Museum, while the second set will be hereafter preserved in the Paris Museum.

1. Hylobates leucogenys Og.

♂. 102, 104 (young). ♀. 46, 103. Xieng Khouang, Laos.
♂ (young). 182. Savannaket, Laos.

These Gibbons are of much value as helping to clear up the confusion in which the species and subspecies of the genus still remain.

Firstly, they show that in the Siam and Tonkin Gibbon, the male is constantly black with contrasted white cheek-patches, as described in *H. leucogenys*, and that the female is yellowish or straw-coloured, with a black crown, as described by Pousargues in his *H. henrici* †, of which the present specimens are practically topotypes. We thus get a definite decision about the latter animal, learning that it must be considered as the female of *H. leucogenys*, with the type of which the male specimens from Tonkin absolutely agree.

Furthermore, a comparison of the type of *H. gabriellæ* Thos. with the Delacour males shows that it is readily distinguishable by its cheek-patches being buffy instead of white.

A suggestion has been made to me that this difference may be due to the type, still unique, having been skinned out of spirit, which is a possibility that must not be ignored, although there is no indication in the specimen that it has ever been in spirit.

Mr. Delacour informs me that, after being yellow in babyhood, *both* sexes of this animal turn black, and that the female again turns yellow when becoming adult. The difficulty of sexing specimens, already extreme, is thereby rendered greater, as, except in the fully adult, the colour gives no guide to sex.

* Not to be confused with the Col des Nuages in Tonkin, incidentally mentioned in the paper on Mr. Stevens's Mammals.

† Bull. Mus. Paris, ii. p. 367, 1896.

2. Pygathrix nemæa L.

♂. 190. ♀. 14. Col des Nuages, Annam.

Examples of this wonderfully coloured monkey are still very rare in collections, so that these specimens form a highly acceptable accession.

I would reiterate the opinion published in 1911, that *nemæa* and its close ally *nigripes* should be treated as representing a genus distinct from *Pithecus*, differing both by their external proportions, their remarkable coloration, and the characters of the base of the skull.

3. Pithecus phayrei Bly.

♀. 156. Xieng Khouang.

Previously known from Burma and Siam.

4. Macaca arctoides Geoff.

♀. 200. Col des Nuages, Annam.

For this Macaque I use Geoffroy's name, as being undeniably pertinent, and agree with Blanford that F. Cuvier's name of *speciosus*, typeless and without locality, should be altogether dropped, in view of the conflicting views that have been published as to its identification. Elliot makes out a fairly plausible case for its appertaining to the present species, but completely ignores Temminck's case for its being the Japanese Macaque. The locality of *speciosus* being quite uncertain, while that of *arctoides* is definite, the dropping of the former name will clearly tend towards the simplification of the subject.

5. Nycticebus bengalensis Geoff.

♂. 41. Xieng Khouang.

Very similar to the specimens from the Naga Hills, Assam, presented by Messrs. Hutton and Mills, which were the basis of my note on the nomenclature of the Northern Slow Loris*.

The condylo-basal length of the skull is 65 mm., in marked contrast to that of *N. pygmæus*, in which it is only about 52 mm.

6. Nycticebus pygmæus Bonh.

♂. 288, 377. Kontoum, Annam.
♀. Hué.

7. Pteropus vampyrus malaccensis K. And.

♂. 214. Hué.

A considerable extension of the known range of the species. Mr. Kloss obtained it in Siam.

* J. Bomb. Soc. xxviii. p. 433, 1922.

8. Cynopterus sphinx Vahl.

♂. 284. Kontoum, Annam.

9. Megærops ecaudatus Temm.

♀. 356, 357 (in al.), 358. Dak-to, Annam.

This is a very rare Bat, and a valuable accession, for the Museum collection only previously contained two specimens of it, from Kina Balu, Borneo, and Bidor, Perak. It has thus a very wide geographical range.

10. Rhinolophus sp.

♂. 15. Col des Nuages, Annam. 400 m.

11. Hipposideros sp.

♂. 2. Col des Nuages, Annam.

12. Pipistrellus sp.

♂. 273. Kontoum, Annam.
♂. 230. ♀. 24 (in al.). Hué, Annam.

13. Tylonycteris pachypus Temm.

♀. 327, 328. Dak-to, Annam.

14. Scotophilus castaneus Horsf.

♂. 223 (in al.). Quang-Nghai, Annam.

15. Myotis sp.

♂. 265, 266. Kontoum, Annam.

16. Tupaia belangeri tonquinia Thos.

18 from Xieng Khouang, Laos, 4 from Col des Nuages, Annam, 3 from Muongsen, Annam, 1 from Kontoum, and 1 from Dak-to.

17. Hylomys suillus siamensis Kloss.

♀. 52. Xieng Khouang.
♂. 290, 292, 322, 329, 335, 336, 337, 338, 363, 364. ♀. 291, 302. Dak-to.

These specimens agree by their pale fore-back and warmer hind-back with the type from Central Siam, now B.M. No. 20.7.3.12, and equally differ from the darker and more uniformly coloured *H. s. microtinus* of Tonkin, obtained by Mr. Stevens.

18. PARASCAPTOR LEUCURUS Bly.

♀. 49. Xieng Khouang, Laos.

19. CHIMARROGALE VARENNEI, sp. n.

380. Dak-to. B.M. No. 26.10.4.44. *Type.*

Size medium, the skull intermediate between those of *himalayica* and *leander*, decidedly larger than that of *styani*. Colour dark, the upper surface of the usual blackish slaty, with a certain number of silver-tipped hairs intermixed, most numerous on the rump; under surface soiled greyish, little lighter than the upper surface, and not sharply defined. Throat lighter greyish, with an indication of a light band passing backwards below the ear. Hands dull whitish. Feet with their inner halves whitish and their outer brown, but the contrast little marked. Tail uniformly blackish brown throughout, except that there are a few whitish hairs intermixed proximally below.

Skull in shape about as in *himalayica* and *styani*, not of the extreme specialization found in *platycephala*. Muzzle slender. Brain-case high, not so flattened as in other species, its lateral ridges of average development.

Teeth as usual. Size of upper unicuspid normal, decidedly larger than in *styani*, where they are proportionally smaller than in other species. Incisors with the quite rudimentary inner terminal cusp characteristic of true *Chimarrogale*, in contrast with the much more developed cusp found in the insular genus *Crossogale* *.

Dimensions of the type:—

Hind foot 19·2; tail 62.

Skull: median length 25·2; condylo-incisive length 26; anterior breadth 7·5; breadth across brain-case 13·2; height of brain-case from basion 7; upper tooth-row 11·7; unicuspids 3·2; front of p^4 to back of m^2 5·9.

Hab. and *Type* as above.

The dried carcase of this specimen was brought to Mr. Lowe by a native—the skin is therefore in bad condition, but the skull is perfect.

Readily distinguishable by the intermediate size of its skull, its wholly dark tail, and the dull coloration of its under surface. Its locality is further south than that of any other member of the genus *Chimarrogale*, and thus narrows the gap towards the allied *Crossogale* of the E. Indian Archipelago, but in its characters it shows no approach to the latter.

Named in honour of M. Alexandre Varenne, Governor-General of Indo-China, to whom M. Delacour has been much indebted for help in various ways.

20. CROCIDURA sp.

♀. 275. Dak-to, Annam.

* *Cf.* Ann. & Mag. N. H. (9) vii. p. 243, 1921.

21. Felis temminckii Vig. & Horsf.

Native skin. Xieng Khouang, Laos.

22. Felis marmorata Mart.

(Label lost.)

23. Felis bengalensis Kerr.

♂. 73, 135. ♀. 48, 71, 101, 151, and two native skins. Xieng Khouang, Laos.
♂. Quang-ngai, Annam.

24. Viverra zibetha surdaster, subsp. n.

♂. 74. ♀. 174. Xieng Khouang, Laos.
♂. 371. Dak-to, Annam.
♀. 287. Kontoum, Annam.

A race averaging rather smaller than true Indian *zibetha*, and with the bullæ decidedly smaller.

Colour as usual variable, but on the average a clearer grey than in *zibetha* and with less tendency to definite markings on the flanks and hips.

Skull smaller than in *zibetha*, the bullæ averaging smaller and in some cases very much smaller than occurs in the Indian animal.

Dimensions of the type:—

Head and body 700 mm.; tail 395; hind foot 120; ear 62.

Skull: greatest length 131; condylo-basal length 128; zygomatic breadth 62 with interorbital breadth 19·5; inter-temporal breadth 19; breadth of brain-case 40; palatal length 67; greatest diameter of p^4 15·8. Bulla, length of inflated portion from front side of paroccipital process 13, breadth at right angle to last 8.

Hab. as above. Type from Xieng Khouang.

Type. Male, the permanent teeth all up and in use, but the basilar suture not completely closed. B.M. No. 26.10.4.53. Original number 74. Collected 3 January, 1926.

Among the variable races of the Common Indian Civet this form may be distinguished by its comparatively small size, and especially by its small bullæ. The length-measurement of the bulla, as above given, is commonly 17 or 18 mm. in *zibetha*, and may attain to 20.

25. Viverricula malaccensis Gm.

♂. Dak-to, Annam.

26. Pardictis pardicolor Hodgs.

♂. 120, and a native skin. Xieng Khouang, Laos.

27. Paradoxurus birmanicus Wrought.

♂. 223. ♀. 219. Hué, Annam.
♀. 217, 218. Quang-tri, Annam.
♂. 239. Kontoum, Annam.

The young Paradoxure obtained at Nha-trang by Dr. Vassal, and referred by Schwarz to his *P. cochinensis*, is clearly conspecific with the present species, while the type of *cochinensis*, collected in Cochin China or Cambodia by Pierre, is a decidedly smaller animal.

28. Paguma larvata yunalis Thos.

Three native skins. Xieng Khouang, Laos.

29. Arctogalidia leucotis Horsf.

Native skin. Xieng Khouang, Laos.

30. Chrotogale owstoni Thos. (Plates I. & II.)

♂. 157, and a native skin. Xieng Khouang.

The type of this remarkable Carnivore was quite young, with milk-dentition, and the example obtained by Mr. Stevens in 1923 was without a skull, so that the present specimen gives us the first opportunity of examining the adult dentition. Even of this individual, however, the brain-case has unfortunately been cut off by its native captor, so that the general shape of the adult skull still remains unknown.

The adult teeth are, on the whole, very like those of the milk-series, already described and figured *. The incisors, both upper and lower, are similarly broad and spatulate, while the canines, compared with those of *Hemigalus*, are long, slender, curved, and sharp-edged behind—in fact, somewhat like those of a fox. The premolars are more delicate than those of *Hemigalus*, narrow and elongate longitudinally. P^1 has but a single root, p^3, as in *Hemigalus*, has a small internal cusp, while p^4, the carnassial, is triangular and cuspidate, but much smaller in proportion to the size of the animal. Indeed, all the teeth are peculiarly light and insectivorous-looking, almost suggesting those of *Eupleres*, though far less specialized in that direction. Similarly below, the premolars are essentially of the same structure as in *Hemigalus*, but narrower, more elongate, and more sharply cuspidate. In p_4 the main outer cusp (protoconid) is reduced, while that internal to it (metaconid) is larger, so that the two are almost subequal; and the tooth is remarkably like its predecessor, mp_4, instead of resembling m_1 as is the more usual condition.

The molars, now seen for the first time, are essentially, as in *Hemigalus*, of a more or less primitive multituberculate character, the more specialized "tuberculo-sectorial" condition, so widely spread among Carnivora generally, being here scarcely traceable,

* P. Z. S. 1912, pp. 500–502.

so that the three genera forming the Hemigalinæ, *Hemigalus*, *Diplogale*, and *Chrotogale*, are by this character distinguishable from all members of the Order.*

The muzzle of the adult is peculiarly broad, low, and flattened, with the anteorbital foramina much broader than high. As shown in the young, the snout is remarkably drawn out anteriorly, the premaxillæ lengthened, with wide gaps between i^3 and the canine, and between the canine and first premolar. Below, again, the lengthening is very marked, the wide gap between the canine and p^1 and the consequent elongate spoon-shape of the lower jaw being most striking. The curious long septal foramen between the two palatal foramina is of full proportionate size in the adult, forming a character absolutely unique.

The following are the available measurements of the imperfect skull:—Zygomatic breadth (c.) 43 mm.; palatal length 61; nasals 29 and 9; interorbital breadth 19·5; height of crown above posterior palate 23; front of i^1 to back of m^2 55·6; front of canine to back of m^2 41·5; cutting-edge of i^2 3·5, of i^3 3·8; p^4, length on outer edge 6, oblique diameter 6·6; m^1 5·4 × 4·5; front of lower canine to back of m_2 47; crown of i_3 4·3; p_4 7·4 × 2·7; m_1 6·9 × 3·7; m_2 4·3 × 3.

This fine adult specimen of *Chrotogale* is a most valuable and interesting accession, and gives clear evidence by the structure of its molars, hitherto unknown, of the position of the genus in the

* Apropos of the question of the greater or lesser simplicity of teeth, and the deductions to be drawn therefrom as to the greater or lesser primitiveness of their owners, I venture to remark, anent Mr. Le Gros Clark's recent paper on *Ptilocercus* (P.Z.S. 1926, p. 1296), that he appears to me to have made his deductions the wrong way round. He asserts that as being more simple, less cuspidate, than those of *Tupaia*, the teeth are therefore more primitive.

This view of the matter is so usual that Mr Clark is quite to be excused for taking it, but, in agreement with the opinions of Dr. Forsyth Major and Mr. Hinton, I have come to exactly the opposite conclusion, and consider that it is the complicated, highly cuspidate tooth which is primitive and the simple one specialized. In mammals generally I believe that the process of evolution has been by the loss of cusps, rarely or never by their fresh development.

On this view, so far as its teeth are concerned, *Ptilocercus* is a more highly specialized animal than *Tupaia*

As above stated, *Chrotogale* and its allies *Hemigalus* and *Diplogale* have therefore very primitive dentitions, in marked contrast to those of other Viverridæ.

Naturalists are far too much disposed to speak of animals as "primitive" or "specialized," when there is hardly one in which there is not a mixture of characters, some primitive and others specialized. An obvious case is that of the Platypus, with the most primitive teeth of all mammalia—recalling those of Mesozoic Multituberculata—combined with the highly specialized beak and method of life, these latter having enabled it to survive on to the present day in spite of its generally low organization. And the characters of *Chrotogale* are similarly mixed—primitive molars and specialized skull

So every reference to an animal as being primitive or specialized needs the most careful consideration, and a true view of the bearing of this dentition question, cuspidate or simple, is essential before any advance can be made. I would therefore reiterate my opinion, which is at one with those of Dr. Forsyth Major and Mr. Hinton, that it is the complicated cuspidate tooth which is primitive, and the simplified and "trituberculate" one which is specialized, the Cat specialized and the *Chrotogale* primitive, a view absolutely the other way round from that held by the advocates of the tritubercular theory.

Hemigalinæ. These animals, by their primitive and more multituberculate molars, are readily distinguishable from the other Carnivora, which have progressed in different degrees through the "tuberculo-sectorial" dentition until the high specialization found in the Felidæ has been reached. But while the molars are primitive, the skull and incisors of *Chrotogale* are highly specialized—no doubt for some form of food or habits about which we have as yet no information.

Mr. Willoughby Lowe tells me that *Chrotogale* has a long thick neck, with a peculiarly small head at the end of it, giving the animal a quite unusual appearance.

Not the least of the peculiarities of *Chrotogale* is its striking resemblance in colour to *Hemigalus*, but, in view of their many essential differences, I find it impossible to form an opinion as to whether there can be a common origin for this coloration. It is certainly not mimicry, as the two do not occur in the same locality.

31. Herpestes urva Hodgs.

♂. 162 and a native skin. Xieng Khouang, Laos.

32. Herpestes exilis Gerv.

♂. *a*, *b*. ♀. *c*. Hué.
♂. 195. Col des Nuages, Annam.
♂. 387. ♀. 388. Thula-hun, Annam.

Practically topotypes.

33. Charronia flavigula Bodd.

♀. 359. Dak-to, Annam.
♂. 378. ♀. 372. Kontoum, Annam.

These specimens represent Kloss's subspecies *indochinensis*, but, with its type before me, I feel somewhat doubtful as to the distinction of that form from true *flavigula*. It was separated on account of being smaller and with naked soles, but the type-skull, female, is of just the size of female *flavigula* skulls, while its soles are no more largely naked than is frequently the case in that animal. Bonhote's reference to the soles of *peninsularis* and *henrici* as "naked" in contrast to "hairy" may have given the impression that in *flavigula* they were wholly hairy, but that is by no means the case, a large part of the sole being naked in all.

34. Mustela kathiah Hodgs.

♂. 84. Xieng Khouang, Laos.

35. Melogale personata laotum Thos.

♂. 23. ♀. 215. Hué, Annam.
♂. 260. Kontoum, Annam.

The terminal hairs of the tail are white to their roots, while in

the *Helictis*, otherwise so similar externally, their basal halves are brown or slaty. In the *Melogale* the nuchal line is continuous, but in the *Helictis* it is commonly broken.

The shape of the rhinarium is also evidently different in the two animals, broad and blunt in the *Melogale*, long and pointed in the *Helictis*, but spirit or flesh specimens would be needed for its proper description.

36. Helictis taxilla Thos.

♂. 85, 121, 152. ♀. 45, 72, 86, 158, and a native skin. Xieng Khouang, Laos.

First obtained by Mr. Stevens at Ngai-tio, Tonkin.

These specimens uniformly agree with the type and differ from *H. moschata* by the small size of the skull, its slender muzzle, and narrow palatal tube.

37. Lutra tarayensis Hodgs.

♀. 58 (young). Xieng Khouang, Laos.

38. Helarctos malayanus Raff.

♀ (imm.). Quantri, Annam.

39. Petaurista lylei badiatus Thos.

Native skin. Xieng Khouang.

Not so characteristically rufous as the type from Tonkin.

40. Petaurista annamensis Thos.

282 (native skin). Kontoum, Annam.

Type-locality, Nha-trang.

41. Petaurista marica Thos.

27 (native skin). Xieng Khouang, Laos.

More yellow and less rufous than the type from Yunnan, but these Flying Squirrels always vary considerably. Upper surface profusely spotted.

42. Hylopetes alboniger Hodgs.

♂. 349. ♂. 350. ♀. 360, 362. Dak-to.
♂. 374. ♀. 373. Kontoum.

43. Hylopetes spadiceus Bly.

♂. 248. Kontoum, Annam.

Apparently rare, but widely distributed. Examples are in the Museum collection from Upper Burma (*Fell*), Arrakan (*Phayre*), Cambodia (*Mouhot*), and Cochin China (*Pierre*).

44. RATUFA GIGANTEA McCl.

Native skin. Xieng Khouang, Laos.

45. CALLOSCIURUS FLAVIMANUS I. Geoff.

The re-discovery of this early-described species is of value for the clearing up of Squirrel-nomenclature. *S. flavimanus* was described in 1832 *, and therefore antedates most Oriental Squirrels, but, owing to the difficulty of identifying it, and a doubt as to its exact locality, the name has been thrust aside, and is even omitted in Robinson and Kloss's very complete list of Oriental Sciuridæ.

Fortunately, however, the matter is now beyond doubt, for not only do the Delacour specimens from the Col des Nuages precisely agree with the original description, but another early French author †, to whom the type would have been accessible, records an example from Tourane, quite close to the same locality, and is evidently of opinion that he is thus clearing up the confusion of locality occurring in Geoffroy's first account, a confusion that has none the less persisted to the present time, and is only now dissipated by the Delacour collection. The species in its typical form is readily recognizable by its grizzled olive-grey upper surface, maroon under surface, bright buffy muzzle, ears, hands, feet, and tail-rings, the end of the tail being also washed and annulated with buffy.

The Col des Nuages being quite close to Tourane, specimens from there may be treated as practically topotypes of *flavimanus*.

But among the fine series in the Delacour collection, from four different localities, there would appear to be no less than four different forms of *flavimanus*, agreeing with each other in general coloration, but differing in various slight characters which are practically constant locally, and therefore should be recognized subspecifically.

These may be diagnosed as follows:—

CALLOSCIURUS FLAVIMANUS FLAVIMANUS Geoff.

♂. 4, 7, 8, 16, 20, 185, 193, 194, 207, 209, 212. ♀. 3, 10, 11, 17, 22, 186, 191, 198, 199, 202, 203. Col des Nuages, 400 m.; inland of Tourane.

General colour above strong olive-grey. Maroon of under surface not or scarcely extending forwards on to throat. Grey edging to maroon quite clear grey, without yellowish suffusion or whitening on the thighs. Tail liberally washed with buffy.

Then towards the north in Laos we have

CALLOSCIURUS FLAVIMANUS QUANTULUS, subsp. n.

♂. 31, 39, 47, 54, 169. ♀. 36, 55. Xieng Khouang, Laos.

♂. Crown above about as in *flavimanus*, or rather more yellowish. Maroon of under surface generally extending up

* I. Geoff. Mag. Zool. Classe I. Mamm. 1832.

† Gervais, Voy. 'Bonite,' i. p. 40, 1841.

the middle line of the throat to the chin. Grey body-colour where it edges the maroon on each side decidedly suffused with yellowish, and at a point opposite the genitalia there is a yellowish or whitish patch about half an inch broad and an inch or two long. Other characters as in true *flavimanus*.

Dimensions of type:—

Head and body 215 mm.; tail 205; hind foot 50; ear 24.

Skull: greatest length 55 mm.; condylo-incisive length 49·7.

Hab. as above.

Type. Adult male. B.M. No. 26.10.4.96. Original number 31. Collected 19 December, 1925.

On the other hand, to the southward we have in Annam

CALLOSCIURUS FLAVIMANUS DACTYLINUS, subsp. n.

♂. 341, 353. ♀. 243, 352, 369. Dak-to, north to Kontoum.

General colour above of a paler shade of grey than in *flavimanus*, the reddish under surface also of a less deep maroon. Limbs, muzzle, and ears yellow, rather paler than in *flavimanus*. A lighter thigh-patch sometimes indicated. Tail-hairs quite without the deep buffy terminal rings found in the previous forms, uniformly ringed with black and dull whitish.

Dimensions of type:—

Head and body 232 mm.; tail 223; hind foot 49; ear 22.

Skull: greatest length 54 mm.; condylo-incisive length 49·8.

Hab. as above.

Type. Adult female. B.M. No. 26.10.4.101. Original number 243. Collected 16 March, 1926.

And, again, still further to the south there occurs

46. CALLOSCIURUS FLAVIMANUS CONTUMAX, subsp. n.

♂. 255, 258. ♀. 228, 270, 383. Kontoum, S. of Dak-to, Annam. Alt. 550 m.

General colour as in *dactylinus*, the tail similarly without buffy rings. But the muzzle, ears, and proximal part of the limbs are also grey, practically without, or with very little, buffy suffusion, the hands and feet, however, still being yellow, and so preserving the general character of the species.

Dimensions of type:—

Head and body 220 mm.; tail 228; hind foot 49; ear 23.

Skull: greatest length 55·7 mm.; condylo-incisive length 50·8.

Hab. as above.

Type. Adult female. B.M. No. 26.10.4.104. Original number 228. Collected 27 February, 1926.

The two southern subspecies are sharply separated from the two northern by the absence of the buffy terminal rings on the tail-hairs.

47. CALLOSCIURUS ERYTHRÆUS subsp.

Native skin. Xieng Khouang, Laos.

Perhaps most nearly allied to *C. e. nagarum*, but too imperfect for exact determination.

48. CALLOSCIURUS IMITATOR Thos.

♀. 159. Xieng Khouang, Laos.
♂. 177. ♀. 179. Muong-sen; province of Vinh, Annam.

Additional material of this remarkable Squirrel, discovered by Mr. Stevens, is very acceptable. The previous specimens were from Thaï-Niên, Tonkin.

49. TAMIOPS RODOLPHEI M.-Edw.

Seven from the Col des Nuages, seven from Kontoum, and ten from Dak-to.

50. TAMIOPS sp.

♂. 28, 44, 133, 134. ♀. 29. Xieng Khouang.

Perhaps *T. macclellandi laotum* Rob. & Kl. Have somewhat the appearance of *T. m. manipurensis* Bonh.

51. DREMOMYS RUFIGENIS subsp.

♂. 9, 18, 19, 188, 197, 208, 210, 211. ♀. 5, 187, 201. Col des Nuages, Annam. 400 m.
♂. 30, 37, 43, 53, 61, 62, 113, 127, 166. ♀. 63, 87, 110, 167. Xieng Khouang, Laos.
♂. 259. ♀. 252. Kontoum, Annam.
♂. 361. Dak-to, Annam.

The subspecies of *Dremomys* are less tangible than those of *Callosciurus*, and I cannot at present satisfy myself as to what races should be recognized among the present series, nor what names should be used for them. This is partly because the earliest name, *D. r. fuscus* Bonh., type-locality Nha-trang, was based on specimens that have perhaps been altered in colour by preservatives, so that until fresh topotypes of it have been obtained we cannot fix on a name for the ordinary *Dremomys* of Annam.

52. MENETES BERDMOREI subsp.

♂. 251, 268, 283. ♀. 256, 257, 375, 381. Kontoum, Annam.
♂. 334, 342. ♀. 346. Dak-to, Annam.

These specimens are in several different phases of pelage, so that it is difficult to make a definite determination. Perhaps they may best be referred to *M. b. consularis* Thos.

53. Bandicota jabouillei, sp. n.

♂. 213 (aged). Tourane, Annam. 13 Feb., 1926. B.M. No. 26.10.4.143. *Type.*

(?) ♀. 301 (quite young). Dak-to, Annam.

A large Bandicoot of the *B. gigantea* group, those hitherto known from Indo-China being of the smaller *B. nemorivaga* group.

General external appearance very much as in typical *B. gigantea*, of the same coarsely lined blackish grey, with long black hispid piles on the back. Under surface lighter grey, lighter than in *gigantea*, not sharply separated laterally. Head like back, but the area round the mouth and below the jaws is a dull whitish, no such whitish area occurring in the available specimens of *gigantea*. Feet and tail as in *gigantea*.

Skull very large, the length of the type-skull exceeding that of any specimen of *gigantea*, while its height, from tooth-row to crown, is considerably greater than in the Indian animal. In general shape it is proportionally narrow, with long slender muzzle and little expanded zygomata. In the hinder aspect of the skull the great height and the lesser breadth are very noticeable. Supraorbital ridges heavily developed, and extending backwards to the lambdoid crests. Palatal foramina more open. Bullæ larger.

Incisors deep ochraceous in front, about as in *setifera*, those of *gigantea* comparatively pale. First molar of the one specimen with two minute middle external roots, other large Bandicoots having usually only one in this position; the two posterior roots sub-equal, while in other members of the group the outer is larger than the inner. How far these characters are likely to be constant, I am not at present prepared to say.

Dimensions of the type:—

Head and body 344 mm.; tail 245; hind foot 55; ear 32.

Skull: greatest length 66; condylo-incisive length 65·5; zygomatic breadth 35; height from alveolus of m^1 to crown 21·5; nasals 24·6 × 7·7; interorbital breadth 8·2; mastoid breadth 23·5; palatilar length 35; palatal foramina 11; length of bullæ 11·5; upper molar series (crowns, much worn) 10·2.

Hab. and *Type* as above.

This Bandicoot is related to the large *B. gigantea* and *malabarica* of continental India, and to *B. setifera* of Java, but has a longer skull than any of them. None of these large Bandicoots have hitherto been found in Further India, those known from there being of the *B. nemorivaga* group, which are considerably smaller, and which we should have more naturally expected to find in Annam. Mr. Lyle found one of the latter group, *B. mordax* Thos., in Northern Siam. Named in honour of M. Pierre Jabouille, Administrateur, Inspecteur des Affaires Politiques de l'Annam.

54. Rattus bowersi And.

♂. 59. ♀. 126. Xieng Khouang, Laos.

55. Rattus edwardsi Thos.

♂. 65, 115, 160. ♀. 116, 117. Xieng Khouang, Laos.

56–58. Rattus spp.

About 60 specimens.

Besides the large *R. bowersi* and *edwardsi* there are a large number of medium-sized members of the genus *Rattus*, but at present I find it impossible definitely to determine them. The majority appear to belong to what has been called the *fulvescens* group, and others to the *rattus* group. One seems nearly related to *R. surifer*.

59. Chiromyscus chiropus Thos.

♀. 289, 304. Dak-to, Annam.
♂. 106. Xieng Khouang, Laos.

Rather older, and even more richly coloured, than the specimen obtained by Mr. Stevens at Bao-ha, Tonkin. The "amphoral" shape of the skull very well marked.

60. Chiropodomys gliroides Bly.

Six specimens. Dak-to, Annam.

Mr. Wroughton in his Synopsis used the name *peguensis* for this species, on the ground that *gliroides* is not determinable, but, as the locality for *gliroides* is known, and only one species occurs over the whole of the Burmese area, I do not think we can say that this is the case, and therefore continue to use the earlier term.

61. Vandeleuria dumeticola Hodgs.

♀. 56, 57. Xieng Khouang, Laos.

Immature. Determination provisional.

62. Leggada pahari Thos.

♂. 175. ♀. 136. Xieng Khouang, Laos.
♀. 294. Dak-to, Annam.

63. Mus dubius Hodgs.

Fourteen specimens from Kontoum and Plei-cou, Annam.

This determination, like that of the specimens in the Stevens collection, is of necessity merely provisional, as the complexities of the *Mus-Leggada* group are such as to demand quite a special study, with more material than is yet available.

64. Hapalomys delacouri, sp. n.

Seven specimens, adult and immature. Dak-to. Annam.

Size much less than in the only previously known species, *H. longicaudatus*, a native of Tenasserim and S.W. Siam. General

appearance very much as in *longicaudatus*, the long soft fluffy fur, tufts of fine hairs round the ears, the structure of the feet and tail all very much as in the larger animal. Hairs on back about 10 mm. in length. General colour above dull buffy, below pure white throughout. Head uniform in colour, like back ; no darker rings round eyes. Ears pale brown, not darker than the head. Hands and feet thinly haired, brownish white. Tail proportionally less long than in *longicaudatus*, the scales very coarse, 9 to the centimetre, not hidden by the feeble penicillation of the terminal half, which is less developed than in *longicaudatus*.

Skull barely more than half the bulk of that of *longicaudatus*. Nasals very narrow for their posterior half. Zygomata very abruptly and squarely projected anteriorly, the supra-foraminal bridge comparatively slender, not notched when viewed from above, the zygomatic plate not being projected forward, its front edge quite vertical. Supraorbital ridges well developed, though anteriorly not so heavy as in *longicaudatus* ; posteriorly, however, they extend, well-marked, right across the parietals to the outer corners of the interparietal, while in *longicaudatus* they disappear halfway across the parietals. Bullæ much smaller than in *longicaudatus*.

Incisors very heavy. Molars with the characteristic structure of those of *longicaudatus*, though they are rather smaller in proportion, m^1 not so broad as the palate between it and its fellow. M^1 not so sharply rectangular as in *longicaudatus*, and with the minute cusplets in front of the main anterior cusps scarcely developed. Lower molars also with the highly peculiar structure found in *H. longicaudatus*, with the same extra external main cusps, although in the minute cusplets there are certain divergencies which may or may not prove to be constant.

Dimensions of the type :—

Head and body 136 mm. ; tail 150 ; hind foot 20 ; ear 14.

Skull : greatest length 34·3 mm. ; condylo-incisive length 32·2 ; zygomatic breadth 18 ; nasals 12 × 3·6 ; interorbital breadth 4·4 ; breadth of brain-case 14·4 ; palatilar length 15·3 ; palatal foramina 6·5 ; length of bulla 6·4 ; upper molar series 6 ; lower molar series 6·5.

Hab. as above.

Type. Adult male. B.M. No. 26.10.4.183. Original number 347. Collected 17 March, 1926.

This animal, scientifically the most interesting of the novelties obtained by the expedition, I have named in honour of the distinguished naturalist Mr. Jean Delacour, to whose keenness and enterprise the present important exploration of Annam is due.

The discovery of this species is of great interest, as hitherto the genus *Hapalomys*, described in 1859, has remained monotypic, the one species, *H. longicaudatus*, being still very rare. Its dentition is of a very remarkable character, owing to the presence —probably one should say persistence—of a third, outer, main row

of cusps in the lower jaw, all other Muridæ having only two rows. No doubt, the third row is homologous with the outer cingular ledge occurring in a number of genera, but in none is this ledge broken up into the well-developed cusps that we find in *Hapalomys*. In the present new form the structure is essentially as in *H. longicaudatus*, although there are slight differences in the development of certain of the supplementary cusplets on the molars.

As a species *H. delacouri* is at once distinguishable from *H. longicaudatus* by its much smaller size, and this distinction is carried still further in the next animal, which is, again, a further diminutive of the same type—the three species, all very like in general characters, representing three widely separated size-stages.

65. HAPALOMYS PASQUIERI, sp. n.

♂ (young). 70. Xieng Khouang. B.M. No. 26.10.4.185. Collected 1 January, 1926. *Type.*

Apparently similar in all respects to the last species, but much smaller, as is shown by the reduced size of the molars. The colour of the type is greyer, less buffy, but this is probably due to the fact that it is quite young. The ear-tufts are more profuse, and the tail is rather more uniformly hairy.

Skull of type too young for its characters to be described, the distinction of the species resting on the considerably smaller molars, whose structure appears to be quite the same as in its larger relatives. The incisors are, perhaps, less conspicuously short and heavy.

Dimensions of the type:—

Head and body 91 mm.; tail 103; hind foot 17; ear 14.

Skull: greatest length 26; condylo-incisive length 24; upper molar series 5·3; lower molar series 5·6.

Hab. and *Type* as above.

A more northern representative in Laos of *H. delacouri*; readily distinguishable by its smaller molars, the general characters appearing to be very much the same, so far as can be judged from a single immature example.

Named in honour of M. Pierre Pasquier, Résident Supérieur en Annam.

66. RHIZOMYS SENEX Thos.

♂. 119. ♀. 118, 162. Xieng Khouang, Laos.
♂. 331. ♀. 274. Dak-to, Annam.
♀. 280, 281 (very young). Kontoum.

The two baby specimens, Nos. 280 and 281, are snowy white throughout, a characteristic of which I know no previous record. Mr. Willoughby Lowe states that their eyes were black, and their feet and tail reddish flesh-coloured. They are very remarkable-looking little objects, and might be suspected of being something wholly different, had we not their skulls for comparison;

all the more that their feet are very small, and not of the disproportionate size usually found in young animals.

Dr. Anderson seems to have seen a number of young Bamboo-Rats of different groups, but does not mention their whiteness, so it is probably not universal in the family.

67. Atherurus macrourus Linn.

♀. 173. Xieng Khouang, Laos.
♂. 221, 222. Thua-Lenon, Hué.

These Porcupines both in skin and skull agree better with the Malayan *A. macrourus* than with the Tonkin *A. stevensi.* They have no trace of the peculiar under-coat of white woolly hairs found in the latter.

68. Lepus vassali Thos.

♂. 216. Hué, 19 February, 1926.

The type-specimen of *L. vassali*, from Nha-trang, is immature, and the present example shows that the species attains practically the same size as *L. siamensis* and *peguensis*. It is distinguishable from the former by its nearly wholly white belly, without the large amount of ochraceous which covers the sides of the belly in that species. And from *peguensis* it is separable by its more or less buffy-coloured instead of white feet. Its nape is dull drabby rufous, not ochraceous as in *siamensis*.

The type of *L. hainanus* Swinh. is also quite young.

69. Capricornis sp.

3 frontlets. Nong-het-koo, Laos.

70. Muntiacus sp.

279, 376, 382. Kontoum, Annam.
Frontlet. Nong-het-koo, Laos.

The skins are those of mere fawns, two of them still in the spotted phase.

71. Tragulus kanchil affinis Gray.

226, 249. Kontoum, Annam.

72. Paramanis javanica Desm.

♂. 237, 267 (juv.). Kontoum, Annam.

4. Some Australian Freshwater Entomostraca reared from Dried Mud. By ROBERT GURNEY, M.A., F.Z.S.

[Received October 20, 1926: Read February 8, 1927.]

(Text-figures 1–11.)

The Entomostraca described below have been reared during the past four years from samples of mud sent to me by Mr. F. L. Berney, of Longreach, Queensland, to whom I wish to express my gratitude. These samples, which Mr. Berney despatched in 1921 and 1924, were from localities in the neighbourhood of Longreach—"Blackboy Lagoon," "Whistling Duck swamp," and a hole in thick timber (Gidea Scrub). All these pools are filled only after rains, and are subject to periods of drought which may last twelve months or more.

The number of species reared has not been large, and no doubt represents but a small fraction of the species actually living in these pools when they are full; but the large proportion which prove to be new to science shows that the Entomostracan fauna of Australia, though far from being an unexplored field, is by no means fully known. A number of Ostracoda have been reared and preserved, but have not yet been worked out.

For our knowledge of the Australian Entomostraca we are indebted mainly to Prof. G. O. Sars, who has with conspicuous success exploited the method of hatching from mud, but the literature of the subject is already rather extensive.

Miss Henry has summarised the information available as regards the Entomostraca of New South Wales, and her papers include a bibliography in which most of the papers dealing with Australia and New Zealand are mentioned. There are, however, some important omissions, and I have therefore thought it worth while to append a chronological bibliography which I believe to be complete, at least down to the publication of the 'Zoological Record' for 1924.

BRANCHIOPODA.

APUS AUSTRALIENSIS Spencer & Hall.

1896. Sars, Arch. f. Math. Nat. xix.

A single female specimen developed in 1922 in one of my aquaria, and lived for some time in apparent health: but it died before attaining complete maturity. At the time of death it had reached a total length of 16·5 mm., and a few eggs were found to have been extruded. These eggs formed a small clotted mass attached to the front of the 12th legs, and had not entered the brood-chamber of the 11th pair. The animal during life had

the shield of a green colour, while the ventral surface and legs were brick-red.

The specimen described by Sars was still smaller (13 mm.), and was probably a male. He noted certain differences from the description of Spencer and Hall, but attributed them to variability. Miss Henry has examined a number of specimens, and finds there is much variation, not only in the proportional dimensions, but also in some details of structure. My own specimen agrees very closely with that of Sars, but differs in the following characters:—

(1) The dorsal carina, though not very pronounced, is distinctly traceable to the cervical sulcus.

(2) The posterior ventral edge of the carapace is denticulated to a greater extent. Miss Henry notes great variation in this character.

(3) Only 10 somites are limbless. In Sars's specimen there were 12, and Miss Henry gives 12 or 14 without stating the sex.

(4) The nuchal organ is almost circular, whereas it is heart-shaped in Sars's figure.

I may add to Prof. Sars's description that the mandible has eight tubercles; only one pair of rudimentary antennæ is retained; the telson is smooth on its ventral surface, with four small spines round the insertion of the furcal rami.

Table of Measurements.

	mm.
Length of shield—median	10
,, ,, total	11·7
Width of shield	7·5
Total length (end of telson).........	16·5
Length of furcal ramus..............	12
Number of exposed somites.........	22
Number of legless somites	10
Number of teeth on sulcus	37

Mr. Berney tells me that he has himself taken specimens of *Apus* at Longreach which have been named *A. australiensis* at the Queensland Museum.

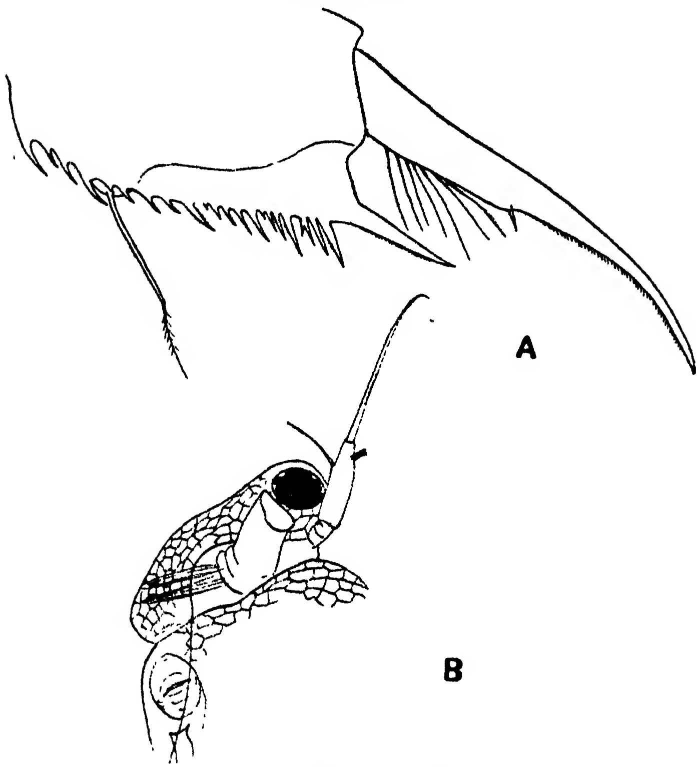
EULIMNADIA RIVOLENSIS Brady.

1903. Sayce, Proc. R. Soc. Victoria, p. 245.

A single male specimen developed in 1922 from mud in company with several *Estheria*, and was not, for that reason, noticed until it attained a considerable size. The specimen agrees exactly with the description given by Sayce, but no lines of growth can be detected on the shell. Brady saw no lines, and Sayce states that they are very difficult to see without staining. The elongated rostrum of the male seems to be the best character by which the species may be recognized.

I give a figure of the telson, since that of Sayce does not seem very satisfactory (text-fig. 1, A).

Text-figure 1.



A. Post-abdomen of *Eulimnadia rivolensis* (Brady). Male.
B. *Ceriodaphnia dubia*. Head of male.

ESTHERIA BERNEYI, sp. n. (Text-figs. 2, 3.)

Shell of the same shape in both sexes.

Female. Length 5·1 mm., height 3·3 mm.

Male. „ 4·45 mm., „ 2·75 mm.

Dorsal edge straight or very slightly concave, with a distinct posterior angle; umbo prominent, very near anterior end; lines of growth fringed with setæ and for the most part very distinct—14 in female specimen and 16 in male. In the latter the last three lines are crowded together and indistinct. Spaces between lines marked with radial "tubules" and pits.

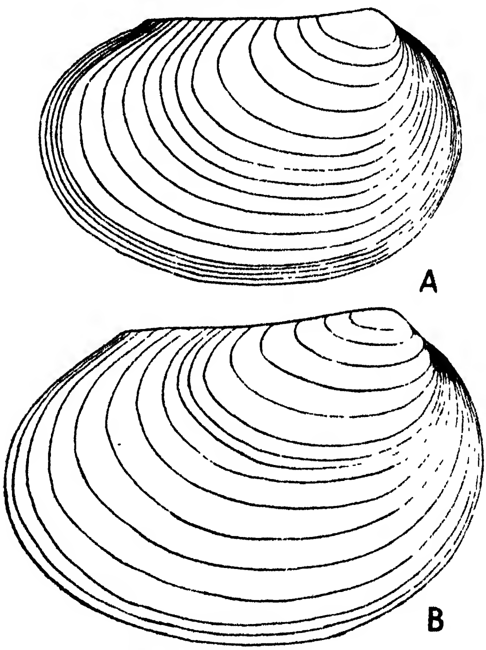
Head in both sexes of about the same shape; the rostrum sharply pointed and the posterior part scarcely at all prominent.

Telson differs little in the two sexes. Terminal claws long

and slender, with a row of small denticles on their dorsal face and a group of setæ at their base. Dorsal margin of telson with a number of small teeth and two conspicuously larger teeth.

Somites :—23 somites were counted in each of the two specimens examined. In lateral view the dorsal processes of the last two or three somites appear as single spines; the somites following have from one to five accessory lateral spines. The size of the processes and the number of lateral spines increase

Text-figure 2.



Estheria berneyi, sp. n.
A. Shell of male. B. Shell of female.

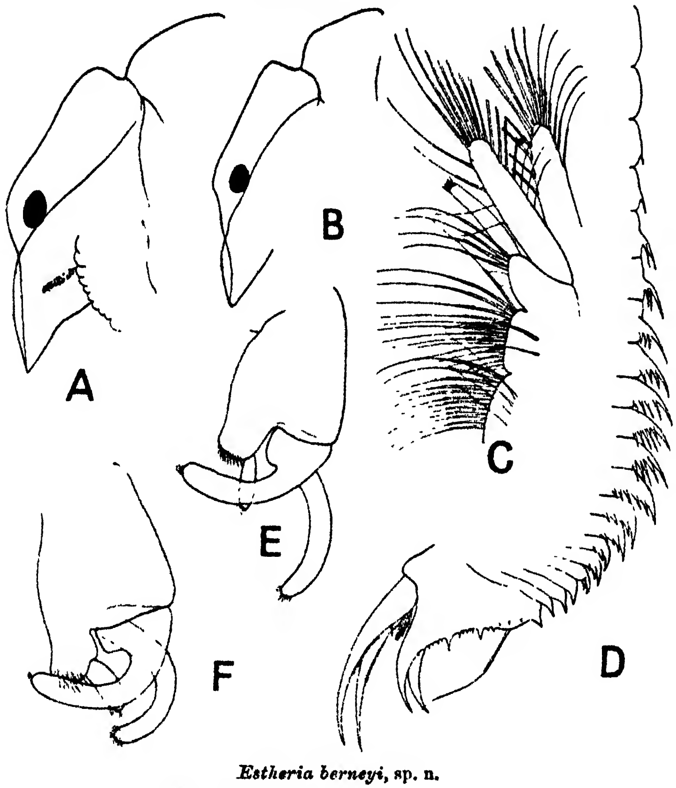
up to the eleventh and then decrease again. The four anterior somites have neither dorsal processes nor spines.

Appendages :—The first leg of the female and the third leg of the male bear long "endital palps." The prehensile hand of the first leg in the male is larger than the second, but differs little in structure. The terminal endite or cushion, on which the claw is apposed, bears a number of spines but no setæ. The inner face of the hand is not indented. On the posterior face of the second pair is a group of setæ, but there are none in this position on the first leg.

A number of larvæ hatched from mud in June 1922, but only two, a male and a female, were reared to maturity.

It is rather remarkable that a single valve which certainly belonged to *E. lutraria* was found in the same parcel of dried mud, but the living animals reared were of quite a different

Text-figure 3.



Estheria berneyi, sp. n.

A. Head of male.
B. Head of female.
C. Part of first leg of female.
D. Post-abdomen and dorsal spines of female.
E. Clasper of first leg of male.
F. Clasper of second leg of male.

species. It is possible that both species were hatched, but only one came to maturity. The larvæ examined differed in no respect from those of *E. packardi* described by Sars. The large upper lip of early stages is simply rounded, and has not the three large prongs found in some other species (e. g. *E. ticinensis*, *E. syriaca*).

The species here described resembles most closely *E. elliptica*

Sars, of which only the female has been described. It differs from it in having a marked posterior-dorsal angle on the shell, in the character of the markings on the shell, and in the arrangement of the dorsal spines on the telson. In *E. elliptica* the terminal claws have no basal setæ.

The species falls within the group included by Daday in his genus *Cœnestheria*, but the characters by which the genera are separated by him do not seem of sufficient importance to justify generic distinction, and it is preferable to retain the name *Estheria* in its original and wider sense. This name is, it is true, condemned by the Rules of Nomenclature, but it is firmly established in literature, admits of no ambiguity, and should be treated as a *nomen conservandum*.

BRANCHINELLA AUSTRALIENSIS Richters.

Larvæ of some Anostracan appeared repeatedly in my aquaria, but in almost all cases died long before reaching maturity. Three specimens reached a stage in which the adult characters were partly acquired, and these I refer with some doubt to *B. australiensis*. The male agrees more closely with Sayce's description than the female, in which the 2nd antenna, though rather long, is not by any means as long as in the adult.

CLADOCERA.

DIAPHANOSOMA UNGUICULATUM, sp. n. (Text-fig. 4, A–D.)

Length of *female* 1·36–1·51 mm.

Head erect, broad, not very deeply marked off from carapace; its greatest width is approximately equal to its height. Length of carapace about two and a half times the height of the head. Shell-valves not in-turned at ventral margin, fringed with slender setæ; the posterior angles and margin without denticles, but with very minute cilia.

Eye comparatively small; its diameter about one-third the width of the head in the eye-region.

Second antenna not reaching nearly to end of shell.

Post-abdomen of usual form. Claws very long and curved, armed with small denticles along the whole length.

Male, length 1·15 mm. Scarcely differing from female.

First antenna longer than in the female, and bearing a long delicately-ciliated flagellum or seta which reaches back nearly to the end of the 2nd antenna.

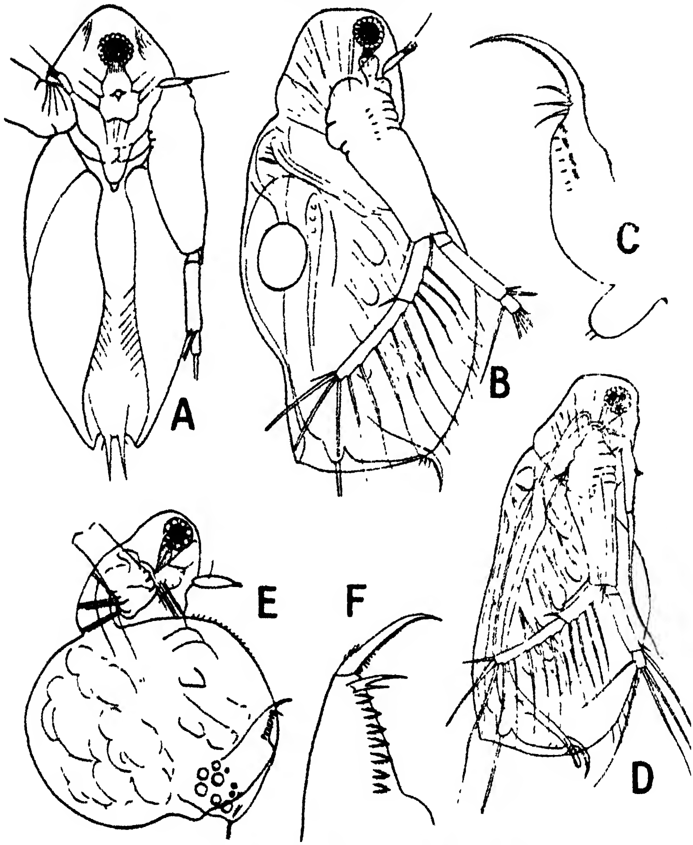
Post-abdomen as in female, except for the possession of the penis of usual form.

This species hatched out in May in several aquaria and persisted throughout the summer, though never becoming very numerous. In August it was found that the majority had resting eggs and that a few males had appeared. Some specimens even survived into the winter.

I am reluctant to found a new species in a genus in which

specific differences are so slight, but it is impossible to identify this one with any hitherto described. It is quite distinct from

Text-figure 4.



Diaphanosoma unguiculatum, sp. n. A–D.
A. Ventral view of female.
B. Lateral view of female with resting egg.
C. Post-abdomen of female.
D. Male.
E. *Moina dubia* Richard. Female.
F. Post-abdomen of female.

the widely-distributed *D. excisum*, which has an inflected shell-margin.

CERIODAPHNIA DUBIA Richard. (Text-fig. 1, B.)

See Stingelin, Mém. Soc. Neuchât Sc. Nat. v. 1913, for synonyms.

This species appeared in small numbers in the summer of 1922, and males and ephippial females were found in July.

Some of the females with summer eggs had a very conspicuous posterior prolongation of the shell, but there was much variation in this respect, and no trace of this spine was present in the ephippial specimens. They differed also in the extent to which the shell was reticulated, some being conspicuously reticulated all over and others almost without markings. The post-abdomen had no lateral cilia, but the long claws were furnished with a series of minute hairs, those of the middle of the series noticeably longer and stronger than the rest.

Stingelin (1913) has given reasons for the uniting of *C. dubia* and several other species with *C. reticulata*, and indeed there is no doubt a close relationship; but at the same time I cannot, from my own experience of the two species, agree with this union. Although the middle cilia of the claws do form a distinctly stronger series in *C. dubia*, I have never seen any specimens in which they at all approach the stout spines of *C. reticulata*, and there is a further character in which the species differ which is not mentioned by Stingelin—the 1st antenna of the male. This antenna is very short and thick in *C. reticulata*, but it is much more elongated and slender in *C. dubia* (text-fig. 1, B). There can, however, be little doubt that *C. silvestrii* Daday, *C. affinis* Lillj., and *C. limicola* Ekman belong to *C. dubia*, while *C. natalis* Brady and *C. richardi* Sars are properly referred to *C. reticulata*.

MOINA DUBIA Richard. (Text-fig. 4, E, F.)

A few females of a species of *Moina* lived for a time in one of my aquaria, but did not flourish and died without producing males or ephippia. The identification of species of this genus without males or ephippia is a matter of some uncertainty, but I consider these specimens should be referred to *M. dubia*.

Adult female. Length ·9 mm.

Head rather erect, with a shallow depression behind the eye; valves without striæ, the ventral margin with short stiff setæ, the posterior margin with minute denticles. Eye large, its greatest diameter about one-third the head-height. First antenna short, less than one-half the head-height; the posterior margin with or without hairs. Post-abdomen rather slender, the postanal part well defined from the preanal part. Postanal part one-third or less of the whole post-abdomen and bearing eight lateral spines. Terminal claws long and slender, with a row of fine denticles, those at the base distinctly stouter than the rest and forming an ill-defined comb. Preanal part sparsely hairy.

The species of *Moina* previously recorded from Australia are:

M. propinqua Sars.	*M. australiensis* Sars.
M. tenuicornis Sars.	*M. flexuosa* Sars.

With none of these does the species in question agree. In general form it resembles *M. propinqua* closely, but in the latter

the shell-valves are striated, the 1st antenna is longer, and the post-abdominal claws are stated by Prof. Sars to be "without any secondary teeth at the base." From *M. australiensis* the species differs in the fact that in the latter the post-abdominal claws are stated to be "quite smooth."

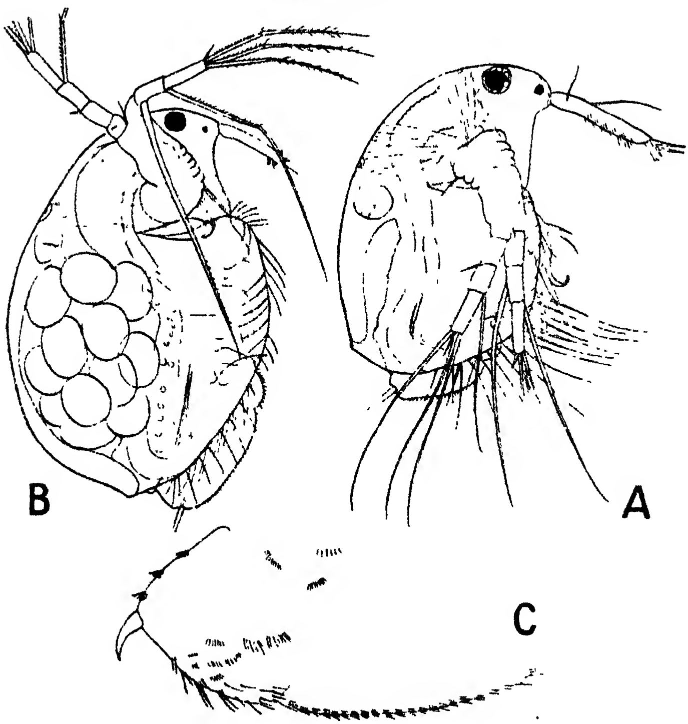
Moina brevicornis Sars from China appears to differ from *M. dubia* only in having the post-abdominal claws quite smooth.

ILYOCRYPTUS HALYI Brady.

Syn. *I. longiremis* Sars.

Hatched out in several aquaria, but never multiplied greatly, nor were males or ephippial females seen.

Text-figure 5.



Macrothrix spinosa (King).
A. Female. B. Male.
C. Post-abdomen of female.

MACROTHRIX SPINOSA (King), Sars. (Text-fig. 5.)

This species became very numerous in some aquaria. In one of these aquaria the first specimen was noticed at the beginning

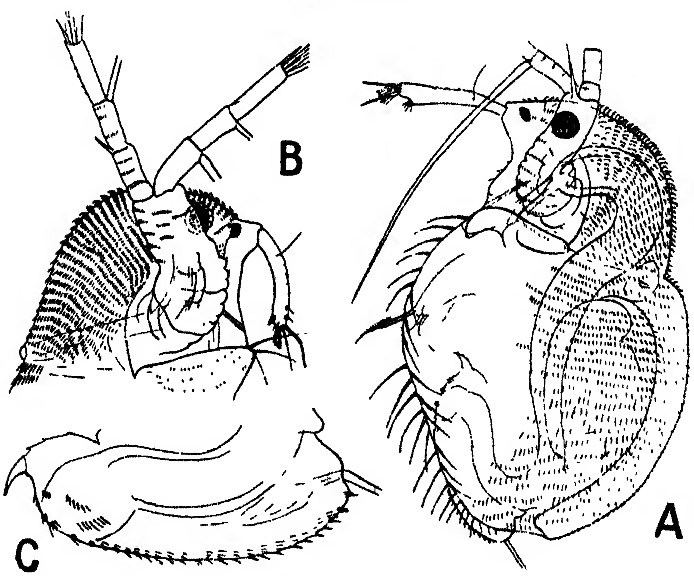
of June, and by the end of the month males and ephippial females were abundant. Numbers then began to decline. The specimens examined agree in most essentials with Prof. Sars's description, but there is one point in which there is serious disagreement, for the dorsal preanal part of the post-abdomen is distinctly not armed with a single row of strong spinules, but with a close series of transversely-arranged groups of spinules. I do not find any reticulation of the shell or serration of the dorsal margin. Sars's figures do not very clearly show the form of the antennæ, and, as there is a certain doubt in my mind as to whether these specimens are correctly referred to his species, I give some figures from which comparison can be made.

It appears to be a common Australian form, and is also recorded from Hawaii, Sumatra, Java, Siam, Singapore, and even South Africa.

MACROTHRIX HYSTRIX, sp. n. (Text-fig. 6.)

Height of the head rather less than half the length of the shell-valves, and marked off from the body by a small notch.

Text-figure 6.



Macrothrix hystrix, sp. n.
A. Female. B. Head of female.
C. Post-abdomen of female.

Just in front of the notch is a small nuchal organ. The eye is large, and in front of it is a slight depression over the ocellus

which gives the outline of the head a very characteristic appearance. The whole dorsal surface of the head is covered with transverse rows of stiff curved spinules, which are very conspicuous along the dorsal margin. The ventral surface is concave and not serrated or with transverse rows of cilia.

The shell is narrowed behind, but with scarcely any posterior angle, and is covered with very minute hairs. The ventral margin is armed, as is usual, with long setæ, but is not toothed.

The 1st antennæ are curved, slightly dilated at the end, and slightly jagged along the anterior margin. There are a few small hairs at the distal end, but the greater part is smooth. The setæ of the 2nd antennæ are very long and not ciliated, but with a small spine at the end of the proximal part. The large spinous seta of the first joint of the anterior branch is smooth.

The post-abdomen has a regularly-curved dorsal margin without any pronounced anal incision, and is armed throughout its length with short transverse groups of spicules.

Length (*female*) ·5–·72 mm.

This species most closely resembles *M. singalensis* Daday which has almost precisely the same shape of head. *M. singalensis*, however, is not hirsute, but has the shell marked with hexagonal reticulations, and it differs also in the shape of the 1st antenna and post-abdomen.

It appeared in several of my aquaria in small numbers, but males and ephippial females were not seen although it persisted into the autumn.

NEOTHRIX, gen. n.

Head large, marked off from thorax by a slight depression; upper lip long, with pointed apex; ocellus large; valves rounded behind. First antennæ long, curved, not dilated at extremity; 2nd antennæ with posterior ramus with three setæ only, anterior ramus with five, the seta of the basal joint very long and spine-like. Post-abdomen without terminal claw. Intestine without coil or cæca.

NEOTHRIX ARMATA, sp. n. (Text-fig. 7.)

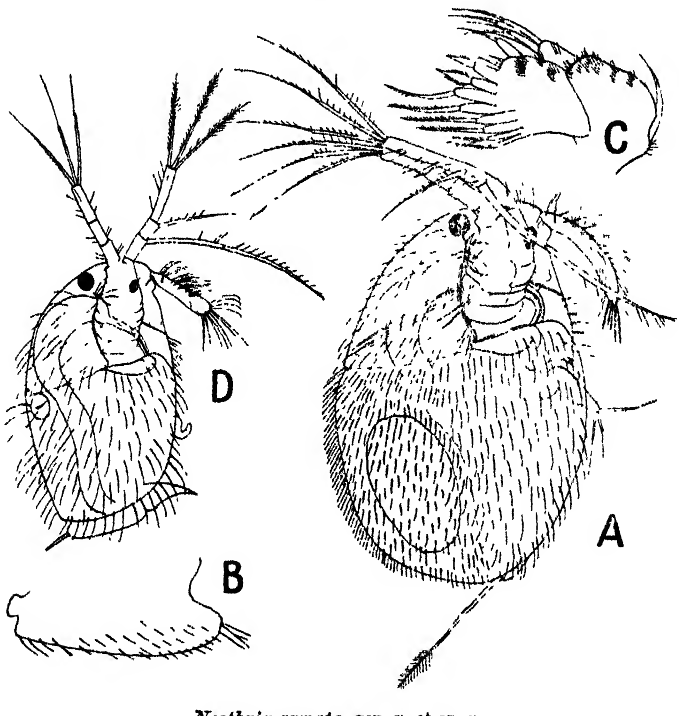
Female. Length ·43 mm., width ·29 mm.

General shape, in side view, ovoid, without any marked angle posteriorly. Head defined from body by a very small depression. Surface of head and the whole of the valves covered evenly by short setæ or slender spines. Dorsal and ventral margins of shell otherwise smooth and without reticulation. Fornix distinct.

Head about equal to half length of valves; its ventral margin straight or slightly convex, and not concave as is usual in *Macrothrix*. The upper lip, which forms a direct continuation of the front and is not distinctly marked off from it, is very large, with a narrow terminal process bearing a number of hairs.

Eye without conspicuous crystalline cones and not greatly larger than the ocellus, which is variable in shape. Post-abdomen with no preanal incision, but a nearly straight dorsal edge armed with a number of delicate setæ, but no serration or spines. There is a dorsal projection bearing the post-abdominal setæ somewhat similar to that of *Lathonura*. The post-abdomen terminates, not in a claw as is general in Cladocera, but in a simple button-like knob.

Text-figure 7.



Neothrix armata, gen. n. et sp. n.

A. Female. C. First leg of female.
B. Post-abdomen of female. D. Male.

First antennæ nearly equal in length to the height of the head, slightly curved, and narrowing to a point at the end. Surface profusely ciliated.

Second antennæ as in *Macrothrix*, but the setal formula is 0 . 0 . 0 . 3 : : 1 . 1 . 3.

The ephippium contains only one egg, and the ephippial area is dark brown with a dense covering of short stout spines.

Male. Length ·29 mm.

Differs considerably in shape from the female, the carapace narrowing behind, and with a distinct postero-dorsal angle. The head is not marked off from the body, and is of the same form as that of the female. Post-abdomen with an incision in the region of the anus, and produced posteriorly into a tapering claw-like form without cilia or spines.

First antennæ straight, widening distally and profusely hairy.

The family Macrothricidæ contains at present 16 genera which may be determined according to the table below, which is founded upon that of Lilljeborg (1900). The genus here described is apparently closely related to *Macrothrix*, but differs from it in the number of setæ on the 2nd antennæ and in the form of the post-abdomen in both sexes. The post-abdomen of the female is indeed quite unlike that of any other genus, but bears most resemblance to that of *Lathonura*, to which genus, however, it has otherwise little relationship. The post-abdomen of the male resembles that of *Echinisca*.

I have, unfortunately, been unable to dissect the five small closely-packed legs sufficiently to give a satisfactory account of them. The first leg is shown in text-fig. 7, C, and resembles fairly closely that of *Wlassicsia* as figured by Birge*, but it appears to have a large sickle-shaped process on the first joint anteriorly which may perhaps represent the epipodite. The fifth pair are very rudimentary and appear to have a very small oval epipodite. Legs 2 and 3 project into the median groove with large gnathobases.

Table for determining the Genera of Macrothricidæ.

(Founded on that of Lilljeborg, 'Cladocera Sueciæ,' 1900.)

1. Intestine with hepatic cæca	2.
„ without these cæca	5.
2. Intestine with coil	4.
„ without coil	3.
3. Shell with dorsal tooth	*Drepanomacrothrix.*
„ without tooth	*Wlassicsia.*
4. Anterior branch of 2nd antenna with setæ 0 . 0 . 3.	*Parophryoxus.*
„ „ „ with setæ 1 . 1 . 3.	*Ophryoxus.*
5. Intestine with coil	6.
„ without coil	8.
6. Posterior branch of 2nd antenna † with 4 setæ	*Streblocerus.*
„ „ „ with 3 setæ	7.
7. Shell with dorsal process	*Drepanothrix.*
„ without dorsal process	*Acantholeberis.*
8. Posterior branch of 2nd antenna with 3 setæ	9.
„ „ „ with 4 setæ	11.
„ „ „ with 5 setæ	14.

* Trans. Wisc. Acad. Sci. xvi. 1910, p. 1038.
† Four-jointed branch.

9. 1st antenna two-jointed	*Ilyocryptus.*
„ one-jointed	10.
10. 1st antenna long and slender; post-abdomen with claw.	*Bunops.*
„ stout; post-abdomen without claw	*Neothrix.*
11. 1st antenna dilated towards end	*Macrothrix.*
„ slender throughout	12.
12. Distinct incision between head and thorax	*Iheringula.*
No incision	13.
13. Preanal part of post-abdomen smooth	*Grimaldina.*
„ „ „ spiny	*Echinisca.*
14. 1st antenna short and thick	*Guernella.*
„ long and slender....	15.
15. Post-abdomen with small dorsal process, tapering	*Pseudomoina.*
„ without dorsal process, not tapering ...	*Lathonura.*

ALONA INTERMEDIA Sars.

As this species has not previously been recorded from Australia, and records of it from other countries are sometimes subject to doubt, it is advisable to give a figure of the characteristic post-abdomen (text-fig. 8, E) in proof of identity.

A few specimens were picked out from among numbers of *A. lævissima* from Longreach mud, but no males or ephippial females were seen.

The post-abdomen is remarkably like that of *A. mülleri* Rich. (=*Alonella karua* King), but the spine at the base of the claw is much longer.

The species is widely distributed, and is reliably recorded from:—British Isles; Norway; Sweden; Germany: South America (Brazil, Paraguay, Peru); South Africa; River Nile; Ceylon; Cochin China.

ALONA LÆVISSIMA Sars. (Text-fig. 8, A, B.)

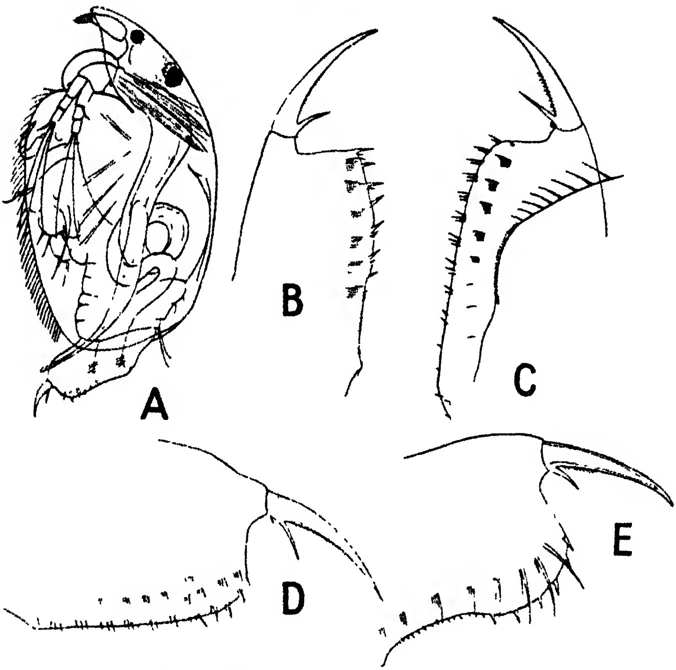
Developed in March 1923, and continued to multiply throughout the summer and following winter, being still numerous in May 1924. Males and ephippial females appeared in the autumn.

My specimens vary greatly in size from about ·37 mm. to ·52 mm. (Sars's measurement being ·48 mm.), and the outline of the shell is also variable. The marginal spines of the post-abdomen also vary somewhat in strength. The normal summer form is rather elongated, with dorsal and ventral margins almost parallel, but the ephippial female has a much more curved dorsal outline and is smaller. The ephippium shows no sign of sculpture and is dark brown or perfectly black.

The male (text-fig. 8, A), which is about ·34 mm. long, differs from the female in its more erect head and the form of the post-abdomen, which is short and broad, the claws being also shorter and stouter than in the female. The posterior dorsal

angle does not project as in the female, and the dorsal margin may be quite smooth or have a few small denticles. The lateral

Text-figure 8.



A. *Alona lævissima* Sars. Male.
B. " " " Post-abdomen of female.
C. *Alonella diaphana* (King). Post-abdomen of female.
D. " " " Post-abdomen of male.
E. *Alona intermedia* Sars. Post-abdomen of female.

bundles of fine hairs are long, the posterior groups projecting beyond the margin.

LEYDIGIA LÆVIS, sp. n. (Text-fig. 9.)

Female. Shell-valves without striation, punctate, but sometimes with very faint hexagonal markings; greatest breadth behind the middle line; anterior margin fringed with very long hairs.

Ocellus scarcely larger than eye, triangular in shape.

Post-abdomen two and a half times as long as broad; dorsal margin evenly curved, armed with a series of about nine long spines decreasing in length anteriorly, the first four with three

long accessory spines at their base, the last four with a single spine. Claws without basal spine but with delicate hairs.

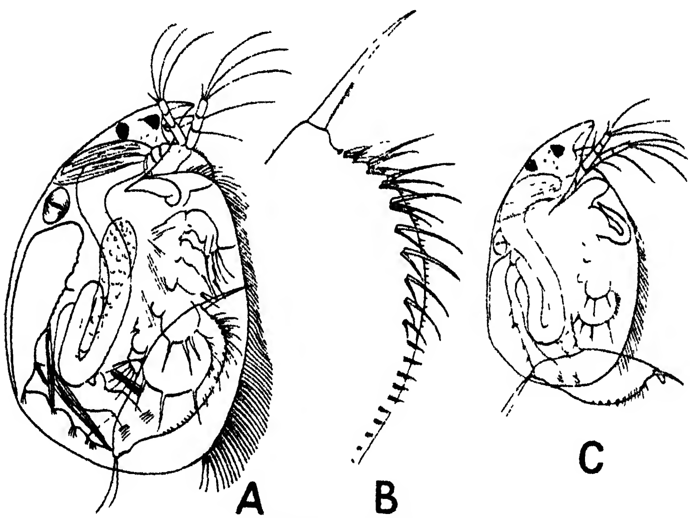
Colour yellowish, with a red tinge anteriorly.

Length ·6 mm.

Male. Of much the same shape as the female, the post-abdomen tapering posteriorly. Length ·3 mm.

The species of the genus *Leydigia* are somewhat difficult to separate, the most reliable characters being the size of the ocellus, the shell-markings, and the presence or absence of

Text-figure 9.



Leydigia lævis, sp. n.

A. Female.
B. Post-abdomen of female.
C. Male.

a basal spine on the post-abdominal claws. The only species that has been recorded from Australia is *L. australis* Sars, from which this new species differs conspicuously in the size of the ocellus and the shape of the post-abdomen. It resembles most closely *L. quadrangularis* and *L. propinqua.* From both it differs in having no basal spine on the post-abdominal claws and in its smaller size. From the former it is distinguished also by the form of the post-abdomen of the male, and from the latter by having no striation on the shell.

Alonella diaphana (King), Sars. (Text-fig. 8, C, D.)

Syn. *A. davidi* Richard.
A. punctata Daday.
A. diaphana var. *punctata* Gurney.

This species hatched in small numbers from mud in 1923 and 1924. A few males appeared, but no ephippial females were seen. The females vary in size from ·50 mm. to ·57 mm., the males being about ·37 mm. There is also some variation in form, the shell being less constricted behind in some individuals than in others. I have already given reasons for uniting *A. davidi* and *A. punctata* under the same species *, and these specimens confirm my opinion, agreeing in structure of the post-abdomen with that of specimens from Egypt.

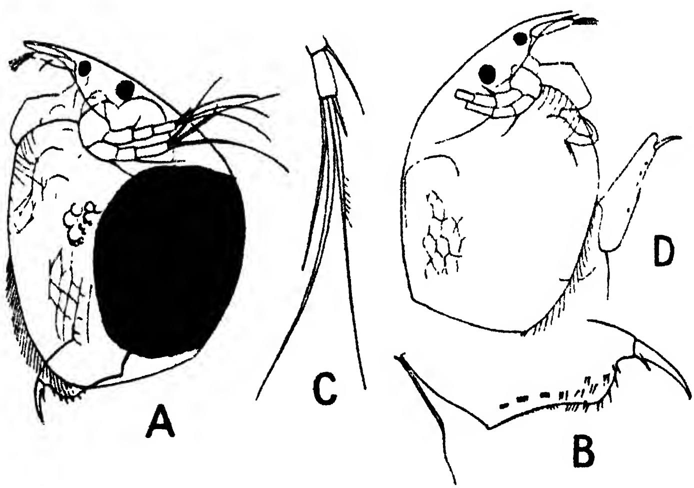
ALONELLA MACROCOPA (Sars). (Text-fig. 10.)

Alona macrocopa Sars, 1894, Christ. Vid. Selsk. Skr., M.N. Kl. no. 5.

Alonella duoodonta Henry, Proc. Linn. Soc. N.S.W. xlvii. p. 49.

These two species are, I believe, identical, though there are

Text-figure 10.



Alonella macrocopa Sars.

A. Ephippial female.
B. Post-abdomen of female.
C. Last joint of anterior branch of 2nd antenna.
D. Male.

certain obvious differences between the figures of Prof. Sars and those of Miss Henry. Some of these differences may be

* Ann. & Mag. Nat. Hist. (8) vii. p. 30 (1911).

explained as due to individual variation. The following characteristics of the species may be specially noted :—

(1) The 1st antenna is flattened, so that it appears long and slender in side view, and much broader if viewed from behind or rotated slightly.

(2) The terminal setæ of the large 2nd antennæ are very characteristic. On the posterior branch the anterior seta is shorter than the other two, and the middle seta is slightly the strongest, the joint in it marked by a projecting spine and the proximal part with about five short prickles. The anterior branch bears a spine on the first joint, a short stiff seta on the second, and three long setæ on the third. Of these three, one is short and quite slender; one is long, stout, spine-like, and smooth, except for a spinule at the joint; while the third has a similar spinule at the joint and also a series of prickles on its proximal half.

Prof. Sars, in his original description, drew attention to the unusual size of the antenna; but this is not alluded to by Miss Henry.

(3) The valves are fringed with long plumose setæ, and generally have one or a pair of stout spines at the ventral angle, as described by Miss Henry. But these spines may often be absent, or absent from one valve and not the other. These spines are a characteristic feature of *A. duoodonta*, but are evidently a character not sufficiently constant to distinguish it from *A. macrocopa.*

(4) The upper lip often, but by no means always, has a small protuberance, which is figured by Miss Henry but is not shown in Prof. Sars's figure. This, again, cannot be regarded as a fixed distinguishing character.

If it were not for the fact that Prof. Sars definitely states that his *A. abbreviata* differs from *A. macrocopa* in not having strikingly large antennæ, it would be necessary to include this species also in the synonymy. It agrees in size, shape, shape of post-abdomen, and also in possessing a knob on the labrum similar to that of *A. duoodonta* and some of my own specimens.

A. macrocopa is recorded from New Zealand; *A. abbreviata* and *A. duoodonta* from New South Wales.

The boundary between the genera *Alona* and *Alonella* is so ill-defined that some species may with almost equal justice be referred to either. I consider that this species, by reason of its shape, elongate acute rostrum, and the form of the post-abdomen of the male, falls more naturally into the *Alonella* series than into *Alona.*

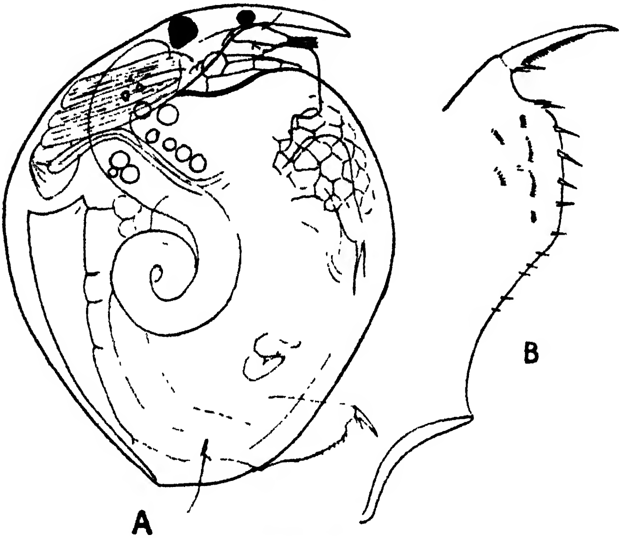
CHYDORUS DENTICULATUS Henry. (Text-fig. 11.)

One species of *Chydorus* only developed in my aquaria, but did not become sexual. I refer it with some doubt to *C. denticulatus*. Miss Henry does not give any information as to the

form of the upper lip, which, in this genus, is a most valuable chararacter, and her figure of the post-abdomen leaves one rather uncertain as to the arrangement of the marginal denticles. The post-abdomen in my specimen has a general agreement in shape; but there is only a series of about six marginal spines, followed by a few small hairs.

My specimens also differ in having the shell-valves faintly

Text-figure 11.



Chydorus denticulatus Henry.
A. Female.
B. Post-abdomen of female.

reticulated; but this is a point to which not much importance need be attached.

In size my specimens agree with Miss Henry's. In one aquarium a colony of *Chydorus* developed in which all the individuals were covered all over the dorsal half of the shell with small spines; but I am unable to find any other specific difference between them and those from other aquaria.

COPEPODA.

A few specimens of two species of *Boeckella*—*B. oblonga* Sars and *B. triarticulata* (Thomson)—appeared in several aquaria, the former being the commoner. They did not multiply, and I assume therefore that all the eggs produced were "resting eggs."

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5. Revision of the Family Phreatoicidæ (Crustacea), with a Description of two New Species. By Edith M. Sheppard, M.Sc., F.Z.S., Zoological Department, University College, Cardiff.

[Received July 3, 1926: Read February 8, 1927.]

(Text-figures 1-7.)

Introduction.

This work was undertaken at the suggestion of Professor W. M. Tattersall, of University College, Cardiff, to whom I wish to express my sincere gratitude, not only for his generosity in handing over to me his entire collection of the Phreatoicidæ—the greater proportion of which he himself collected while on a visit to Australia and Tasmania in 1914,—but also for much kindly help. The collection included the following material:—

(1) Specimens of *Phreatoicus tasmaniæ* from the Great Lake collected by the late Geoffrey Smith, part of the material on which he founded the species *Phreatoicus spinosus*.

(2) A collection of *Phreatoicus* made by Professor Tattersall in Tasmania during 1914.

(3) Specimens of *Phreatoicus australis* from Mt. Baw Baw, Victoria, kindly presented to Professor Tattersall by Mr. J. Searle, of Melbourne.

(4) Specimens of *Phreatocoides gracilis* and *Phreatoicopsis terricola* given to Professor Tattersall by the late Dr. T. Hall, of Adelaide.

(5) Specimens of *Phreatoicus latipes* from near Coward, Central Australia, given to Professor Tattersall by Professor T. G. B. Osborn, of Adelaide. These specimens were collected at the same place and at the same time as those on which Chilton founded the species *Phreatoicus latipes*.

(6) Specimens of *Phreatoicus capensis* from the Cape given to Professor Tattersall by Mr. Keppel H. Barnard, who described the species.

I should also like to thank Miss Fordham, The University, Liverpool, for collecting specimens of the new Western Australian species *Phreatoicus lintoni* and *Phreatoicus palustris*, and Professor Nicholls, of the University, Perth, W. Australia, for a specimen of his new genus *Hyperœdesipus plumosus*.

In order that the account of this family should be complete in itself, it was thought advisable to insert a short description of

every species, made after examination and comparison with available literature and figures; in the case of those species not represented in the collection, the descriptions were taken from already existing ones.

Order **ISOPODA** Latreille (1817).

Sub-Order *PHREATOICIDEA* Stebbing (1893).

Family PHREATOICIDÆ Chilton (1891).

Historical.

The first known member of this family was described by Chilton in 1882 as *Phreatoicus typicus*, a blind subterranean freshwater Crustacean of New Zealand, and placed by him amongst the Isopods without defining its exact position.

In 1891 Chilton described a second species, *Phreatoicus australis*, with normal eyes, from under stones on a boggy flat near the summit of Mt. Kosciusko, New South Wales. After detailed investigation of this species Chilton concluded that, although the genus has certain Amphipodan characters (the lateral compression of the body; the downward extension of the pleura of the pleon segments to protect the pleopoda; the division of the pereiopoda into an anterior series of four and a posterior of three; the general appearance of the pereiopoda and uropoda), they are only superficial and consequently of little systematic value. He finally formed a new family (the Phreatoicidæ) to contain the genus, and placed it near the Asellidæ amongst the Isopoda.

In 1893 Stebbing formed the Sub-order Phreatoicidea to contain the family; he considered that the possession of such definite Amphipodan characters warranted its separation from all other Isopods.

Since then other species of the genus *Phreatoicus* have been described by Chilton (1894 and 1906), Thomson (1894), Sayce (1900), and Smith (1909), all freshwater species restricted to New Zealand, Australia, and Tasmania; but in 1914 a further species, *Phreatoicus capensis*, was described by Barnard, occurring in streams on the Table Mts., South Africa.

The family has proved to be an ancient one, for in 1918 a fossil form so closely-allied to *Phreatoicus* as to be placed in the same genus was discovered in the Triassic beds of New South Wales, and was described by Chilton under the name of *Phreatoicus wianamattensis*. Besides the genus *Phreatoicus*, the family contains three other closely-allied genera, each with a single species —*Phreatoicopsis*, a large terrestrial form from Gippsland, described by Spencer and Hall in 1896; *Phreatoicoides*, also from Gippsland, found in a small tributary of the Narracan, described by Sayce in 1900; *Hypsimetopus*, found in burrows of the Land Crayfish (*Engæus cunicularius*) near Zeehan, Tasmania, and described by Sayce in 1902.

In 1922 Chilton described a further species which he provisionally assigned to the genus *Phreatoicus* with the specific name of *latipes*. This species proves to be more closely allied to *Phreatiocopsis* than to *Phreatoicus*, but differs from the former sufficiently to justify its being placed in a separate genus to which the name of *Phreatomerus* has been given below.

Since writing the above, two new species, *Phreatoicus lintoni* and *Phreatoicus palustris*, have been described from Western Australia by Nicholls (1924) and Glauert (1924) respectively, as well as a new genus *Hyperœdesipus* with the species *plumosus*, which has been described by Nicholls and Milner (1923).

I have placed these two new species of *Phreatoicus* in the new genus *Phreatomerus* (see above), as they agree in possessing the fundamental characters of that genus. It is interesting to note in this connection that Nicholls (1924) pointed out that *Phreatoicus palustris*, *Phreatoicus lintoni*, and *Phreatoicus latipes* (*Phreatomerus latipes* of this paper) seemed to form a well-defined group with distinct affinities to *Phreatoicopsis*, distinguished from *Phreatoicus* by the shape of the telson, the possession of eyes and of a relatively long first antenna, and the retention of a secondary cutting edge on the right (as well as the left) mandible.

Apart, however, from the relatively long first antenna and possibly the shape of the telson, these characters are not confined to these three species; the more important diagnostic characters seem to be the fusion of the first pereion (2nd thoracic) segment with the head, and the fusion of all, or nearly all, the coxæ with their respective segments.

The term "subconical" as applied to the shape of the telson of some *Phreatoicus* species has led to some confusion; the term was used to describe the shape in side view and *not* as viewed from behind.

In the species of *Phreatoicus* the telson ends in a more or less pronounced postero-dorsal median projection from which the sides of the telson slope outwards and downwards, so that viewed from behind, the shape, as Nicholls (1924) points out, somewhat resembles that of a horseshoe.

In the species of *Phreatomerus* the median dorsal projection is flattened and broader than in the *Phreatoicus* species, so that the end view approximates more closely to that of a horseshoe shape, whilst in *Phreatoicopsis* there is no median projection and the uropoda are attached further forward than in the other genera, so that the sharply truncate end is horseshoe-shaped or even nearly circular in outline.

After careful examination and comparison of a specimen of *Hyperœdesipus plumosus* with one of *Phreatoicoides gracilis*, I have come to the conclusion that the differences between the two are not sufficient to justify the formation of two distinct genera, and have therefore placed *Hyperœdesipus plumosus* in the older genus *Phreatoicoides*.

My reason for this is that the new species conforms to the

generic diagnosis of *Phreatoicoides*; the most obvious differences between the two species are size, the peculiar shape of the propod of the first pereiopod in the male of *H. plumosus*, and the presence of abundant plumose setæ on the pleopoda of this species.

In the comparative table drawn up by Nicholls and Milner (1923) the chief differences between the two genera, apart from those mentioned above, appear to be differences in proportions: in the table the ratio of $\frac{\text{Pleon Telson}}{\text{Cephalon Pereion}}$ is given as $\frac{58}{190}$ for *Hyperœdesipus plumosus* and $\frac{36}{100}$ for *Phreatoicoides gracilis*. My specimen of the former has a similar ratio, but that of the latter has a ratio of $\frac{16}{100}$, which lessens the difference between the two; also, the length of the first pereion segment of *Hyperœdesipus* is given as less than half that of the succeeding one, and that of *Phreatoicoides* as two-thirds. In my specimen of *Hyperœdesipus* the length of the first pereion segment is $\frac{4}{7}$ (more than half) that of the succeeding one, whilst that of *Phreatoicoides* is two-thirds; so that the comparative difference is again reduced.

Lastly, the constriction between the fifth segment and the telson of *Hyperœdesipus* is said to be slight, whilst it is well marked in *Phreatoicoides*; in my specimens it is equally well marked in both.

Definition.

The body is subcylindrical, more or less laterally compressed, with the first thoracic segment and occasionally the second fused with the head; the eyes, when present, are small and laterally placed.

The upper antennæ are short, each with a peduncle of three joints; the lower antennæ each possess a 5-jointed peduncle and a flagellum equalling or exceeding it in length; they do not possess rudimentary exopodites.

The mandible, which carries a 3-jointed palp, has its oral edge divided into a strong molar process separated by a spine-row from an incisor process. Close to the cutting edge of the incisor process is an accessory blade or "lacinia mobilis," which, in the majority of species, is only found on the left mandible. The spine-row, unlike that of *Asellus*, is placed on a raised base which forms a definite process.

The seven pairs of pereiopods are divided into an anterior series of four which are articulated towards the front of their respective segments and are directed forwards, and a posterior series of three which are articulated towards the hinder ends of the segments and are directed backwards; the first pair is always subchelate. The coxæ of the pereiopods are of small size, and, as a rule, the last six pairs are movably articulated with the body.

The pleon consists of six distinct segments of considerable size, the last one of which is fused with the telson; downwardly-directed pleura may or may not be developed. The pleopods are broad, foliaceous, and branchial in function, usually with an "epipodite" present on each of the 3rd, 4th, and 5th pairs; the first pair is similar in both sexes, and the second pair is present in both male and female; the uropods are biramous, styliform, and subterminal.

Morphology.

The following notes deal with several morphological points which refer to the whole family, and of which there is no complete account:—

Maxillæ.

Probably owing to the difficulty of removing surrounding muscle, the entire structure of both the first and the second pairs of maxillæ has been missed. I have employed Hansen's method of placing parts to be examined in a strong solution of caustic potash, but, instead of using the solution cold, it was used hot, with fairly good results; after allowing the parts to remain in the solution until the muscle-fibres had more or less disintegrated, they were washed in water, and either stained in borax carmine and mounted in balsam or mounted direct in glycerine jelly. When examined after this treatment, both pairs proved to be almost identical in structure with those of *Chirodotea entomon*, described by Hansen and figured in Calman's 'Crustacea,' p. 199.

According to Hansen, in the primitive but often still-existing conditions, the axis of each appendage consists of three segments, and in the following descriptions his interpretation of the various parts has been given.

The first maxilla (text-fig. 3 (4)) consists of two endites directed distally and corresponding to the endites of segments 1 and 3 of the primitive axis. The inner endite (L^1) usually bears four or more plumose setæ on its distal truncate extremity; its upper half is about twice as broad as its basal half, which is embedded in muscle and springs from the middle of a basal plate (1); this plate is the first segment of the appendage.

At the outer side of the basal plate is a very small one (2), corresponding to the second segment of the primitive limb, and from its outer extremity the 2nd lobe of the maxilla arises, consisting of the fused third segment and its endite (3 & L^3); the endite broadens distally and bears two rows of short stout spines on its truncated extremity.

In the second maxilla (text-fig. 3 (9)) the three segments are again represented; the first is in the form of a very small plate (1), at the outer extremity of which the second (2) articulates. The latter is large and broad and directly continuous with its endite (L^2), which narrows distally; its rounded extremity as well as its

inner margin is fringed with long setæ, some of which are plumose. Arising from a cup-like depression on the outer distal angle of the 2nd segment is the rod-like 3rd segment (3) of the appendage; it lies in close proximity to the lower part of the second endite, and at its inner distal extremity articulates with its corresponding endite, which divides into two articulating lobes (L^3 & L^4), the outer of which partly overlaps the inner: each lobe is suboblong in shape, with an obliquely truncate extremity bearing a row of long setæ with broad pectinations on one side.

MAXILLIPEDS.

On the inner side of the coxal joint of the maxillipeds of an ovigerous female (text-figs. 1 (4) & 2 (1)) a small rounded lobe is developed which projects backwards into the broad pouch and is fringed with long hairs curved upwards near their distal ends. I am not aware that this feature has been noted previously in the Phreatoicidæ, but it is known in *Asellus* and in certain genera of the Valvifera. A similar plate, better developed, is found in the females of Cymothoidæ and Epicaridea and of some genera of Sphæromidæ. The function of these lobes is undoubtedly, as Hansen suggests, to produce a current of water through the marsupium for the aeration of the embryos.

Calman makes an interesting suggestion that the lobes are possibly homologous with the oostegites of the following somites. Their occurrence in such widely diverse suborders as the Asellota, Phreatoicidea, and Valvifera lends support to some such fundamental origin.

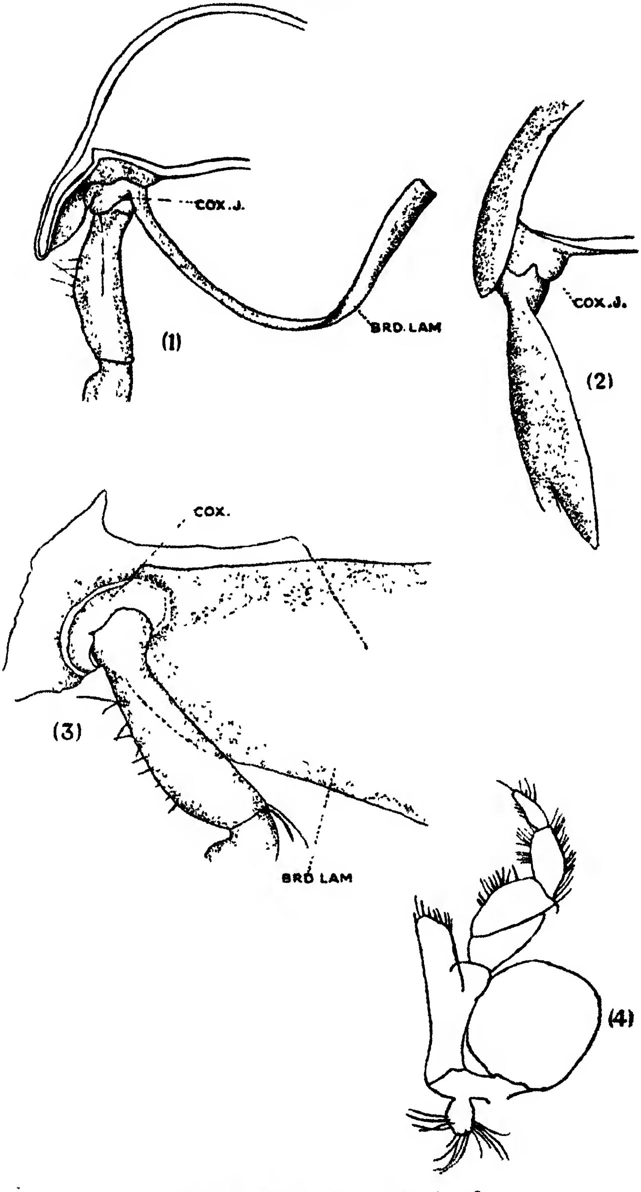
COXOPODITES.

In *Phreatoicus* the coxal joints of the seven pairs of pereiopods are of the type comparable with those found in the Asellota—namely, small but complete segments, more or less movably articulated with the body, except those of the first pair. The articulating margin of the first four coxopodites is rounded and the distal margin bilobed, while the shape of the last three coxopodites is more or less triangular. The conditions are identical in the two sexes, and apparently *Phreatoicoides* and *Hypsimetopus* agree with *Phreatoicus* in the general character of their coxopodites. In the genera *Phreatoicopsis* and *Phreatomerus*, however, a certain amount of fusion has taken place between the coxopodites and the pleura of their somites, and the sexes differ in a rather interesting way in this respect. In *Phreatomerus latipes* this fusion of the coxæ with their somites is associated with a great development of the pleural expansions of the somites.

In the female of *Phreatoicopsis* the coxal joints of the seven pairs of pereiopods are clearly marked off by a suture, and the last six pairs are movably articulated.

In the male, however, only the last three pairs are movably articulated, all the others being fused with their respective

Text-figure 1.



Phreatomerus latipes (Chilton). ♀.

(1) & (3), Portion of segment and basal part of the second pereiopod showing the coxal joint (cox.j.) and brood-lamella (brd.lam.): (1), posterior aspect; (3), ventral aspect; (2), part of the segment and basipodite of the sixth pereiopod (4), maxilliped of female in the breeding phase. (All × 10.)

pleura, though the suture separating them persists to a varying degree.

In *Phreatomerus* the fusion has gone still further, only the coxæ of the second, third, and fourth pereiopods (third to fifth thoracic limbs) of the female of *Phreatomerus latipes* and *Phreatomerus palustris* being free and movable. All the remaining coxæ of the female in these two species and all the coxæ of the male are fused with their respective pleura, but the suture separating them from the basipodites of their respective limbs can be clearly made out. In *Phreatomerus lintoni* all the coxæ are fused to their respective segments in both male and female. In Chilton's description of *Phreatoicus latipes* (*Phreatomerus latipes* of this paper) he states that "nothing is seen that can be definitely recognized as the coxal joint. Consequently it must either have become fused with the pleuron, but, if so, without any suture or mark indicating its presence, or it is quite absent." I have made a careful examination of both male and female specimens of this species, and have found that the coxal joints are undoubtedly present. Text-figs. 1 (1) & (3) represent the basal portion of the second pereiopod of a female with its attachment to the pleuron, looked at from behind and from below. The coxal joint can be seen clearly marked off from the pleuron and from the basipodite, and its identity is established by the oostegite. It is reduced in size compared with the corresponding coxopodite in *Phreatoicus*, but still preserves its bilobed distal margin. The condition to be found in the coxopodites of the last three pairs of pereiopods is shown in text-fig. 1 (2). Here the suture separating the joint from the pleuron has disappeared, but that separating it from the basipodite is clearly visible. The coxal joints in the male of this species are all of this type.

It seems to me clear that the three species *Phreatoicus latipes*, *Phreatoicus palustris*, and *Phreatoicus lintoni* are much more nearly related to *Phreatoicopsis* than to the genus *Phreatoicus*. I have for this reason established a new genus, *Phreatomerus*, for their reception.

The sexual differences in the degree of fusion of the coxal joints found in *Phreatoicopsis* and *Phreatomerus* are specially interesting in view of the fact that comparable sexual differences have been observed in the Oniscoidea, which are otherwise only remotely related to the Phreatoicidea. Omer-Cooper (1923) has described these sexual differences in *Hemilepistus pectinatus* Budde-Lund; and H. G. Jackson has observed similar conditions in certain species of *Ligia*. Dollfus (1893) observed that in the genus *Anomaloniscus* the coxopodites of the second to the fourth pereiopods of the female are marked off by very distinct grooves.

This interesting sexual difference is possibly associated with the fact that the pereiopods concerned are those which in the female bear the oostegites, and with the necessity for a relatively greater freedom of movement on that account.

OOSTEGITES.

There appears to be considerable confusion and inconsistency in the published statements as to the number and form of the oostegites in the females belonging to this family.

Chilton (1894) and Barnard (1914), describing *Phreatoicus australis* and *Phreatoicus capensis* respectively, give the number as three pairs attached to the second, third, and fourth somites of the pereion. Sayce (1900), referring to *Phreatoicoides gracilis*, also gives the number of pairs as three; but I must confess to being unable to understand his statement that they are attached to the "antepenultimate and succeeding two pairs of pereiopods." Miss J. Raff (1912) observes that in *Phreatoicopsis terricola* there are four pairs of brood-plates situated on the ventral surface of the pereion at the bases of the first four pairs of pereiopods, with their upper and outer ends broadly attached to the ridges at the bases of these limbs, the ridges being elevated edges of the sockets into which the proximal ends of the pereiopods fit.

The author, however, does not realize that the "ridges" (see above) to which the plates are attached are the coxopodites of the limbs; further, the description of the position of the plates does not agree with her figure (left side of text-fig. 1), in which the pereiopods, together with the "ridges," are removed, leaving the plates attached to the body.

I have examined females of all the species in the present collection, and in every case I find there are four pairs of oostegites attached to the coxopodites of the first four pairs of pereiopods. The number of brood-lamellæ can, I think, be placed at four pairs throughout the family.

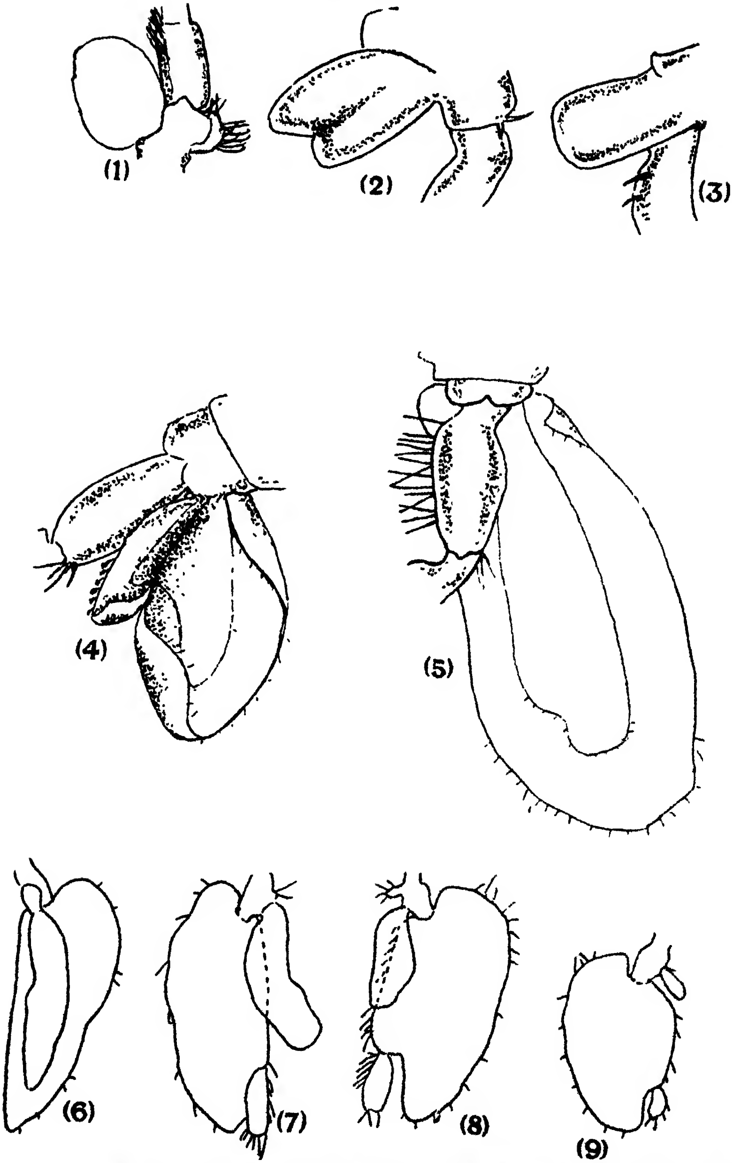
In the course of my examination of the females in this collection I found that the oostegites were present in one of two forms:—

(1) As hard, chitinous, narrow, parallel-sided lamellæ (text-fig. 2 (3)), rounded at their free ends and covering the anterior half of the ventral surface of their respective somites. The lamellæ overlapped their fellows of the opposite side, this overlapping alternating in successive segments (in the first and third segments the left overlaps the right, and in the second and fourth segments the right overlaps the left); but adjacent lamellæ on the same side do not meet or overlap, and the marsupium in this form certainly could not hold eggs.

This form of lamellæ is clearly that seen by Chilton and Raff in the species described and figured by them.

(2) As large thin lamellæ, broadly oval in outline with the margins entire and sparsely fringed with short hairs, overlapping completely to form a perfect marsupium (text-fig. 2 (5)). This is the usual form of the marsupium as known in the Isopods, and was the form seen by Sayce in *Phreatoicoides gracilis*. Specimens having a normal marsupium of this type invariably have eggs or developing embryos in the brood-pouch.

Text-figure 2.



(1), Base of maxilliped of *Phreatoicus australis* (♀), showing the small lobe on the coxopodite (breeding phase); (2) & (3) show the brood-plates on the first and second pereiopods respectively of *Phreatoicus tasmaniæ* (♀) in the non-breeding phase; (4) & (5) same, in breeding phase. (All × 10.)

(6), (7), (8) & (9), are the first, second, third and fifth pleopod respectively, of *Phreatoicoides gracilis* (Sayce). ♀. (All × 10.)

A point of interest presents itself here in the form of the first pair of oostegites, which resembles that of the corresponding pair in the Bopyridæ, although differing from it in details (text-figs. 2 (2) and (4)). Each consists of two parts sharply separated by a deep groove running transversely across the lamella from the point of attachment to the coxopodite of the first pereiopod almost to the distal end, leaving the distal extremities of each part free and giving a bilobed appearance to the whole lamella. The posterior portion is exactly like the remaining oostegites, though smaller. The anterior portion envelops the base of the maxilliped of its side, and has the anterior margin fringed with short plumose hairs: these hairs are not represented in the Bopyridæ. The two portions, at any rate in the Phreatoicidæ, have different functions: the posterior portions simply form the anterior part of the marsupium proper; the anterior parts of each lamella form together an additional aerating apparatus for the marsupium, aiding the coxal lobes on the maxillipeds, which by their movement draw a stream of water through the pouch. The plumose hairs probably act as a filter, which prevents the escape of the embryos with the outgoing flow of water.

According to Unwin's observations on living females of *Asellus aquaticus*, this movement of the coxal lobes on the maxillipeds is of only secondary importance in aeration: the primary movement is produced by the raising and lowering of the oostegites themselves. In the females possessing oostegites of the first form mentioned above the first lamella is slightly bilobed at the distal end. An examination of the brood-lamellæ of *Asellus aquaticus* reveals the fact that the first pair are of almost exactly the same form as in *Phreatoicus*, divided into anterior and posterior portions functioning in the same way as those in the latter genus.

This structure of the first pair of lamellæ in *Asellus* seems to have escaped the notice of earlier workers. Sars does not mention or figure it in his account of *Asellus aquaticus* in the 'Crustacea of Norway,' and Unwin (1920), who has paid special attention to the brood-lamellæ of this species, failed to observe any difference between the first and succeeding pairs.

In attempting to reconcile the descriptions of the brood-lamellæ as given by Chilton and Raff, where the marsupium is obviously incomplete, with that given by Sayce, where it is normal, the most natural explanation which presents itself is that the former authors described immature and the latter author mature females. As the examination of the present collection proceeded, it became evident that this explanation was not an adequate one, for the females with a marsupium of the first type were at least equal in size to those with a fully-formed brood-pouch.

Unwin's recent work on *Asellus aquaticus* provides, I think, the necessary explanation. Incidentally, it may be remarked that Unwin has confused the two British species of *Asellus*. His figures (pl. xxv. figs. 6 & 9) obviously belong to *A. aquaticus* and (pl. xxv. figs. 7 & 8) to *A. meridianus*, and pl. xxv. fig. 9

does not represent an abnormal pleopod of a female *Asellus*, but the second pleopod of the male *A. aquaticus*.

Unwin described two types of female bearing brood-lamellæ. The first type, which he calls the "normal mature female," has four pairs of brood-lamellæ attached to the coxopodites of the first four pairs of pereiopods, which are "small, club-shaped processes." The second type, which is called the "ovigerous" female, has four pairs of large, free, overlapping plates—in other words, a normal marsupium. Unwin kept *A. aquaticus* alive under observation, and discovered that the "normal" type alternated with the "ovigerous" type in successive moults once sexual maturity is reached. The female, after hatching her brood, undergoes ecdysis, and the large functional brood-lamellæ are replaced by the smaller narrow plates of the "normal" type. The female in this condition does not carry eggs or young. In the succeeding moult the fully-formed brood-lamellæ appear and a brood of young is hatched. There are thus two moults or ecdyses between each brood, and the small imperfect form of the marsupium alternates with the large fully-formed one. I have repeated Unwin's observations in so far as they concern this point, and can confirm his results

If the results of these observations are applied to the case of the Phreatoicidæ, it seems clear that the first type of brood-lamellæ described above corresponds with Unwin's "normal" female and the second type with the "ovigerous" female. I should prefer the terms "female in the non-breeding and the breeding phases" instead of "normal and ovigerous." Chilton and Raff's specimens would therefore be in the non-breeding phase and Sayce's in the breeding phase. It seems natural to conclude that the same alternation of breeding and non-breeding phases occurs in *Phreatoicus*. Explained on these lines, the discrepancies in the published accounts of the brood-lamellæ in the Phreatoicidæ disappear.

Further observations are required on *Asellus* to discover whether it breeds all the year round, maintaining a regular alternation of the type of brood-lamellæ continuously once sexual maturity is reached or whether this alternation only goes on during a definite breeding-season, the animals remaining in the non-breeding phase for the rest of the year. Incomplete observations already made suggest the latter course of events.

Kaulbersz (1913), however, has observed that female specimens of *Asellus aquaticus* in aquaria continue to breed all the year round, but under natural conditions the earliest copulating individuals were seen from January to February and were rarely found later than from October to November.

Mrs. Sexton has kindly given me *in litt.* a summary of her observations on the moulting of *Gammarus chevreuxi*, and has allowed me to give a brief *resumé* here as far as they bear on the question of the brood-plates. Mrs. Sexton finds that breeding goes on all the year round, and that there is an ecdysis after each

brood is hatched. The brood-lamellæ are fully formed at each moult and a new brood is reared after each ecdysis. There is thus no alternation of a breeding and non-breeding phase and only one moult between each brood. It would be interesting to know how far this particular case is applicable to the Amphipoda as a whole, and how far the course of events in *Asellus* is characteristic of the whole group Isopoda.

Key to the Known Genera of the Phreatoicidæ.

I. The second thoracic segment is movably articulated with the head	
(i.) Epipodites absent from pleopoda 3–5 .. .	*Phreatoicoides* Sayce.
(ii.) Epipodites present on pleopoda 3–5.	
(*a*) Pleura of pleon segments deep. Pleopoda more or less completely covered ...	*Phreatoicus* Chilton
(*b*) Pleura of pleon segments poorly developed. Pleopoda exposed	*Hypsimetopus* Sayce.
II. The second thoracic segment is fused with the head.	
(i.) Coxæ of the 5th, 6th, and 7th pairs of limbs free ...	*Phreatoicopsis* Spencer & Hall.
(ii.) Coxæ of the 5th, 6th, and 7th pairs of limbs fused with the somite	*Phreatomerus*, gen. n.

Genus PHREATOICUS Chilton (1882).

Phreatoicus Chilton (1882), p. 87.
Phreatoicus Stebbing (1893), p. 388.

Definition:—

Body long, subcylindrical, more or less laterally compressed, with seven free pereion segments; the last six pairs of the coxal joints of the pereiopods are freely articulated with their respective segments. Mouth-parts are normal; eyes small, round, laterally placed or absent.

The pleura of the pleon segments are laterally produced downwards to a depth equal to, or greater than, the segments themselves; the extremity of the telson forms a small projection, varying in size according to the species.

An epipodite is present on each of the 3rd, 4th, and 5th pairs of pleopods.

Key to the Known Species of Phreatoicus.

1.	Eyes are developed	2.
	Eyes are not developed................	7.
2.	Surface of body sculptured and spinous; projection at end of the telson long and acute..	*P. tasmaniæ* (Thomson).
	Surface of body sculptured but not spinous, or surface more or less smooth	3.

3.	Surface of body sculptured; projection at end of telson a little longer than broad, and tipped with 2 spines and 8 long setæ; 3 teeth on both cutting edges of left mandible	*P. brevicaudatus* (Smith).
	Surface of body smooth or slightly wrinkled	4.
4.	Surface of body smooth, with short scattered hairs; lacinia mobilis present on both left and right mandible	*P. capensis* (Barnard).
	Surface of body uneven and wrinkled	5.
5.	Surface of body uneven, and covered with small tufts of microscopic hairs and scattered setæ; lower antenna half the length of the body	*P. tattersalli*, sp. n.
	Surface of body wrinkled, but without tufts of hair; lower antenna one-third the length of body	6.
6.	Surface of body wrinkled, with scattered setæ: pereion segments slender and somewhat separated from each other; basi of 5th, 6th, and 7th pereiopoda expanded .	*P. australis* (Chilton).
	Surface of body uneven, without scattered setæ; basi of limbs not expanded, body compact. Telson with second projection on each side below the terminal one . ..	*P. chiltoni*, sp. n.
7.	Pleura of pleon segments considerably deeper than segment: projection at the end of the telson small and broader than long	*P. assimilis* (Chilton).
	Pleura less than, or equal to, depth of segment	8.
8.	The inner lobe of the first maxilla with nine plumose setæ, the depth of the pleura is less than that of the segments	*P. typicus* (Chilton).
	The inner lobe of the first maxilla with four plumose setæ; the depth of the pleura is as great as that of the segments	9.
9.	Projection at end of telson longer than broad, with 2 or 3 stout setæ and several slender ones; below this the margin is irregularly convex and bears numerous short setæ	10.
	Projection at end of telson very slightly produced, and tipped with 1 stout median and 2 lateral smaller spines and a few long setæ; below this the margin is rounded and bears 1 large and 5 small spines	*P. shephardi* (Sayce).
10.	Base of last three periopoda expanded	*P. kirkii* (Chilton).
	Base of last three pereiopoda less expanded; pereion segments longer, more slender and more separated. .	*P. kirkii* var. *dunedinensis* (Chilton).

PHREATOICUS TASMANIÆ Thomson. (Text-figs. 3 & 4.)

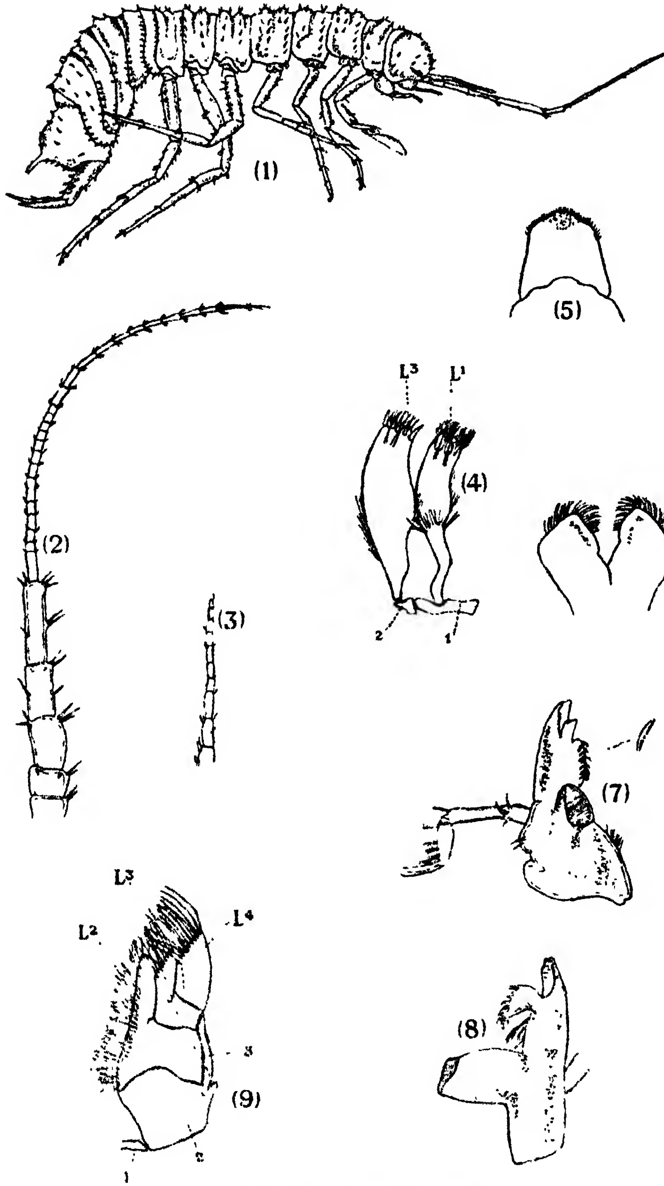
Phreatoicus tasmaniæ Thomson, 1894 (1), p. 76; 1894 (2), p. 349.

Phreatoicus spinosus Smith, 1909, p. 73.

Description:—

A detailed investigation of some of the material on which

Text-figure 3.



Phreatoicus tasmaniæ Thomson.

(1), Adult male, × 3; (2), second antenna, × 5; (3), first antenna, × 5; (4), first maxilla, × 12·5; (5), upper lip, × 10; (6), lower lip, × 10; (7), left mandible, × 12·5; (8), right mandible, × 12·5; (9), second maxilla, × 12·5.

Smith founded his species *Phreatoicus spinosus* has proved that this species is synonymous with *Phreatoicus tasmaniæ.*

The surface of the body is covered with spines and tubercles, which, on segments 2–7, are arranged in two prominent transverse ridges with a depression between.

The cephalon is not as long as the two following segments, and bears, near its anterior margin, two prominent eyes which are laterally placed. The first antenna (text-fig. 3 (3)) reaches to just beyond the fourth joint of the peduncle of the lower one; the peduncle consists of three joints, the first of which is broad and covered with short hair, the second is subequal but narrower, the third is a little longer and more slender than the second. The flagellum is slightly longer than the peduncle and consists of seven joints.

The second antenna (text-fig. 3 (2)) is rather more than half the length of the body; it consists of a peduncle of five segments which is considerably shorter than the flagellum, the length of which varies in different specimens from 20–30 joints. The first two joints of the peduncle are short and covered with short hair, the third is about twice as long as the second, the fourth is a little shorter than the third, and the fifth is as long again as the fourth; the first joint of the flagellum is nearly half the length of the last peduncle joint, the next two or three are short, the remaining ones are subequal, but gradually becoming narrower.

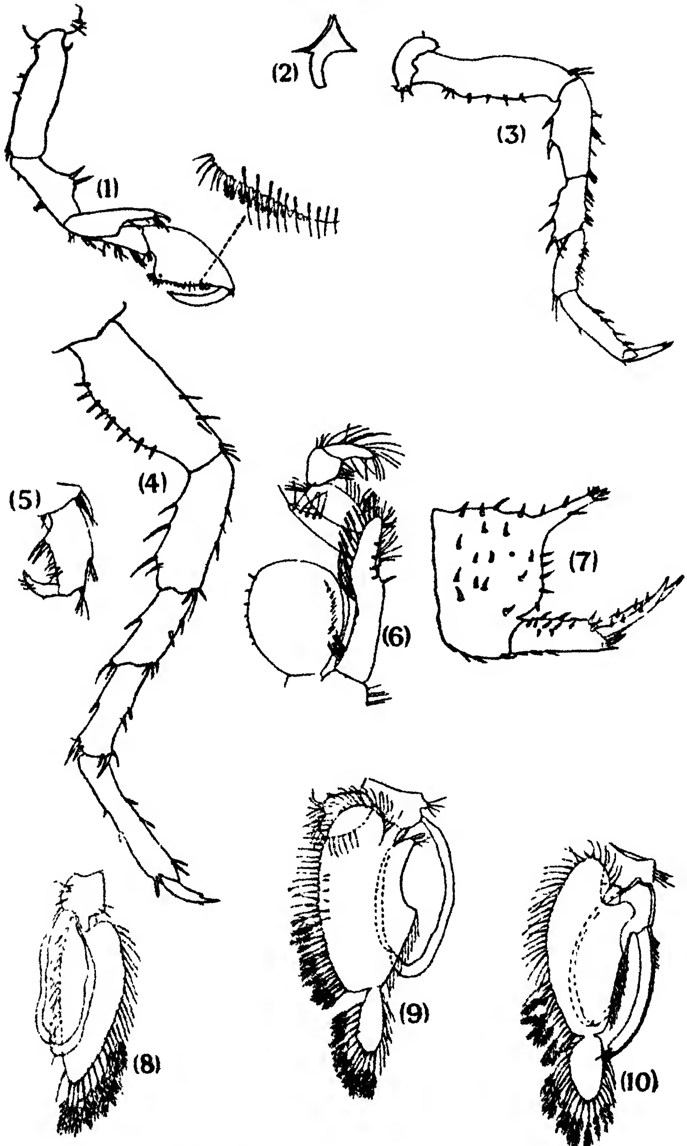
The mandibles are of the usual type; the left (text-fig. 3 (7)) bears four teeth on its cutting edge, whilst three are present on the lacinia mobilis; this latter is absent from the right mandible (text-fig. 3 (8)). The upper and lower lips are very similar to those of *Phreatoicus australis.*

The first maxilla (text-fig. 3 (4)) is made up of two endites of about equal length, one springing from the centre of a flat basal plate, the outer one from a very small plate connected to the outer edge of the inner plate. The distal end of the outer lobe slopes slightly inwards and bears eleven or twelve short, stout spiniform setæ arranged in two rows; the outermost setæ are the largest, and some of them are minutely denticulated on their inner margins. Two simple setæ arise a little below the base of the spiniform setæ, and there is a tuft of long hairs on the outer margin of the basal half.

The distal end of the inner lobe slopes obliquely inwards, and carries four large setæ which are fairly widely separated from each other, and each of which is densely plumose on its distal half. There are also two simple setæ a little below the base of the plumose ones.

The fixed lobe of the second maxilla (text-fig. 3 (9)) has its rounded end and inner margin fringed with long setæ; those of the inner margin are either simple or plumose, while those at the tips are pectinate. The two articulated lobes are about the same size, suboblong, with obliquely truncate extremities sloping slightly inwards, and are supplied, on their inner margins, with

Text-figure 4.



Phreatoicus tasmaniæ Thomson. (♂.)

(1), First pereiopod, × 10; (2), penis, two of which are present on the ventral surface of last thoracic segment, × 10; (3), second pereiopod, × 10; (4), seventh pereiopod, × 10; (5), propodus and dactylus of the fourth pereiopod, × 10; (6), maxilliped, × 10; (7), telson and uropod, × 5; (8), (9), & (10) are the first, third, and second pleopod respectively. (All × 10.)

short, stout pectinations with rounded ends which project at right angles to the setæ.

The maxillipeds (text-fig. 4 (6)) differ slightly from those of the Australian species; the epipodites bear seven or eight short setæ scattered on its outer margin and a narrow band of hairs lying a short distance within the inner margin.

The plate on the basipodite extends distally to beyond the merus as a rounded lobe fringed with long setæ; twelve of these, on the inner margin, are plumose on one side of their distal halves. Near the outer edge of the distal portion are three coupling spines with curved tips, bearing two or three very small rounded teeth.

The ischium is short and carries two groups of setæ, one on each of its distal angles. The merus is subtriangular and has its outer angle produced to nearly the end of the carpus, while the inner margin is only as long as that of the ischium. The inner distal angle is rounded and bears a few long setæ; the outer distal part of the joint is slightly concave for the reception of the carpus, the portion extending out beyond this having its margin fringed with seven long setæ.

The carpus is somewhat narrower at its basal than at its distal end, and sunk in the merus; the distal extremity is slightly flattened, the inner angle rounded, and the inner margin fringed with long setæ. The outer angle is truncated and bears four setæ. The propodus is elliptical, broadest towards its distal end, and has its inner margin fringed with setæ; the outer margin is free from setæ, except for four at the distal angle.

The dactylus is about equal in length to the propodus, but slightly narrower; its apex is rounded. The distal halves of both the outer and inner magins bear long setæ, which are longest and strongest at the apex.

The pereiopods (text-fig. 4 (1), (3) & (4)) are divided into an anterior series of four and a posterior of three; the coxal joints of the anterior series are all similar, consisting of two lobes separated by a deep cleft, each bearing two or three spines on its surface.

The coxal joint of the first leg is slightly deeper than those of the other pairs, and the two lobes are of equal size; in the third and fourth pair the anterior lobe is the larger.

The coxopodites of the fifth, sixth, and seventh limbs are triangular in shape, with the anterior angle rounded, the posterior slightly produced and tipped with a spine; a spine is also present at the centre of the basal margin. The form of the pereiopoda of this species is very similar to that of the pereiopoda of *Phreatoicus australis*, except that the setæ are replaced by spines. The propodus of the first pair of limbs is large and broadly triangular; its posterior margin forms the palm of the subchelate hand, and bears twelve stout spiniform setæ which decrease in size towards the distal end; eight of the longer ones are plumose on their posterior sides.

The fourth pair of pereiopods of the male is modified to form a strong grasping organ. The propodus is shorter and broader than it is in the other limbs; its posterior margin is produced to form a slight eminence, which carries two large, strong, curved spines which, with the backwardly-curved dactylus, form a strong claw (text-fig. 4 (5)).

The pleura of the pleon segments (2–5) are produced considerably, being greater in depth than their respective segments; the fifth segment is about twice as long as the fourth. The lower margin of the pleuron of each is rounded and overlaps that of the succeeding one, and each is fringed with setæ.

The telson (text-fig. 4 (7)) is produced posteriorly into a long narrow projection which narrows slightly and bears two strong spines and five or six more delicate setæ; below this projection on each side the posterior margin is rounded and bears five or six spines, but it becomes slightly concave below for the articulation of the uropods.

The inferior margin in front of the articulation of the uropods is convex and bears four spines, each of which has a minute tooth near the apex of its upper surface.

The pleopods (text-fig. 4 (8), (9) & (10)) are of the usual *Phreatoicus* type and bear a close resemblance to those of *Phreatoicus australis*.

The uropods extend to some distance beyond the end of the pleon; the basal joint is very strong, and equal in length to the outer ramus but twice as broad. The basal half of its lower surface bears three spines, and there is also a group of three at its upper distal extremity, one of which is very large and pectinated on its upper surface.

The upper surface is broad and very slightly concave, with a row of spines along both its edges, those on the outer being more numerous than those on the inner edge.

The rami are similar, except that the inner one is a little longer; they both taper distally, and their extremities are very acute and curve slightly upwards; they bear three stout setæ on the upper surface.

Colour.—"Blackish grey, with the extremities of the antennæ and often of the limbs bright orange" (*Smith*).

Size.—The length of mature specimens varies from about 15–23 mm.

Occurrence.—In the Great Lake of Tasmania (*Thomson*) at an altitude of 3880 ft. above sea-level; among weeds in the littoral zone of the Great Lake (*Smith*); under stones on the shores of the Great Lake as well as in the Lake (*Tattersall*).

Remarks.—Thomson states that the young of *P. tasmaniæ* resemble the adult of *P. australis* in the comparative smoothness of the body and the shortness of the telson. The specimen which he first ascribed to *P. australis* but later concluded was *P. tasmaniæ* was 4 mm. in length. My observations on specimens 5 mm. in length do not agree with Thomson's statement; the

body was quite as spinose as that of an adult, and the telson and uropods were of the typical form.

Phreatoicus brevicaudatus Smith. (Text-fig. 5.)

Phreatoicus brevicaudatus Smith, 1909, p. 73.

Description:—

Owing to the extreme briefness of the existing description, it has been thought advisable to make a more detailed study of this species. The surface of the body is sculptured; each segment is marked by two more or less prominent transverse ridges separated by a slight depression, but, unlike *P. tasmaniæ*, it bears no spines, only a few short scattered setæ.

The cephalon is shorter than the following segments and bears two prominent eyes, laterally placed. The upper antenna (text-fig. 5 (3)) consists of a peduncle of three and a flagellum of six joints, and reaches to the middle of the fifth peduncular joint of the lower antenna. The surface of all the peduncle and of the first two joints of the flagellum is covered with thick short hairs.

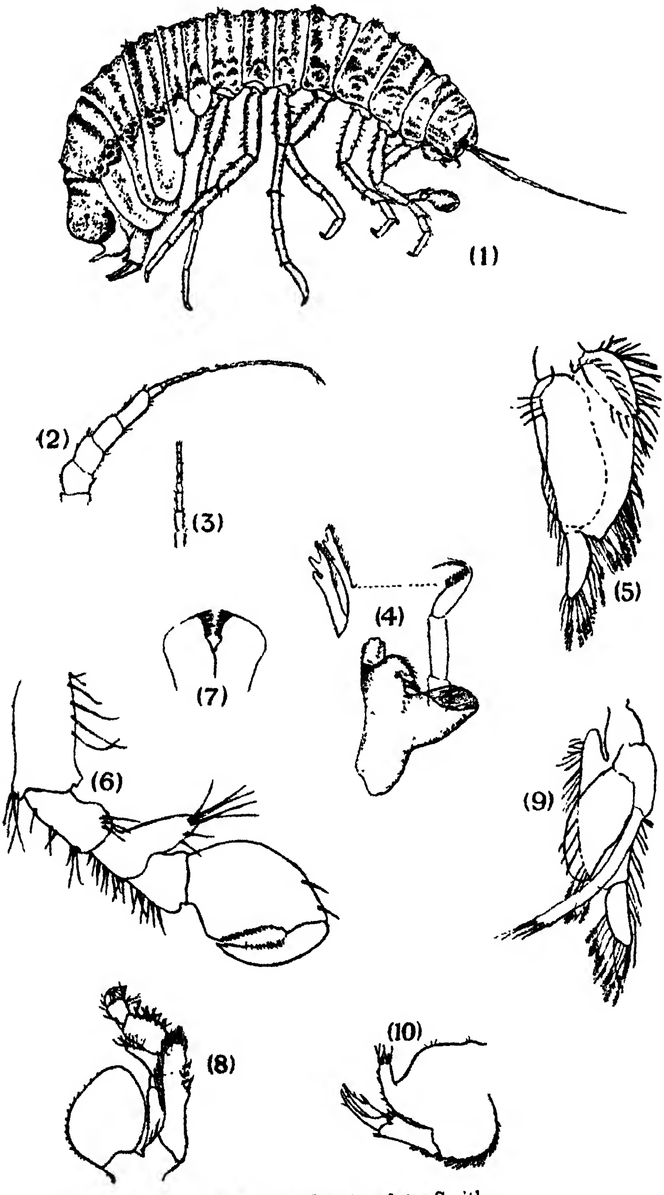
The lower antenna (text-fig. 5 (2)) consists of a peduncle of five and a flagellum of twenty joints; its length is about a third of the length of the body. The surface of the peduncle as well as of eight of the flagellar joints is covered with short thick hair, and not "serrated," as stated by Smith.

The left mandible differs from that of *P. tasmaniæ* in having three teeth on both the incisor process and the lacinia mobilis; there are four teeth present on the incisor process of the right mandible (text-fig. 5 (4)). The mandibular palp consists of three joints, the basal one of which is about two-thirds the length of the second and bears four setæ near its outer extremity; its surface as well as that of the second joint and the base of the mandible is covered with hair. The second joint, unlike that of *P. tasmaniæ*, bears no setæ at its distal extremity. The third joint is characteristic; it bears a single row of eight setæ, the distal one of which is curved and nearly as long as the joint itself; the penultimate one is about three-fourths the length of the distal one, and the others are short and acute. They all bear two or three large rounded teeth on the distal halves of their lower margins and short stiff hairs on their upper margins (text-fig. 5 (4)).

Both the first and second maxillæ are very like those of *P. tasmaniæ*. The outer lobe of the first maxilla bears ten or eleven short, stout, spiniform setæ, while the inner one bears four plumose spines; two plumose hairs are present a short distance from the distal extremity on the outer lobe. The inner margin of the inner lobe is covered with long setæ as well as the lower half of both margins of the outer lobe.

In the second maxilla the two articulating lobes are narrower, and both bear five large pectinate spines; the inner lobe bears one

Text-figure 5.



Phreatoicus brevicaudatus Smith.

(1), Adult male, × 3; (2), second antenna, × 5; (3), first antenna, × 5; (4), right mandible, × 12·5; (5), third pleopod, × 10; (6), first pereiopod, × 10; (7), lower lip, × 10; (8), maxilliped, × 10; (9), second pleopod, × 10; (10), telson and uropod, × 5.

or two smaller ones as well. The apex of the fixed lobe is roundly truncate, and tipped with seventeen long thick setæ, which are plumose on one side. The base of the outer side bears two small groups of short spines like those present on the antennæ.

The upper and lower lips and the maxillipeds (text-fig. 5 (8)) only show slight variations from those of *P. tasmaniæ*; the basipodite of the maxilliped is covered with short hair, and there are seventeen very short setæ on the outer edge of the epipodite.

The pereiopods are broader in comparison with their length, and the spines present in *P. tasmaniæ* are replaced by long setæ.

The depth of the pleura of the third, fourth, and fifth pleon segments is greater than that of the segments themselves; they are rounded below and fringed with a row of setæ.

The upper surface of the telson (text-fig. 5 (10)) is convex, and ends in a projection which is longer than broad. The projection has a truncate extremity which is directed upwards, and not backwards as in *P. tasmaniæ*, and which bears two short spines and a number of longer setæ.

The margin below the projection on each side is convex, and bears six or seven small setæ which decrease in size from above downwards. The inferior margin in front of the articulation of the uropod is convex, and bears sixteen curved spines arranged close together which decrease in size anteriorly. Except for the posterior two or three, each spine has a couple of small teeth on its upper surface close to the tip.

The uropoda are shorter than those of *P. tasmaniæ*, and do not project far beyond the end of the telson. The basal joint is stout, about equal in length to the outer ramus, with nine scattered setæ on the lower margin of the basal half. The upper surface is slightly concave, and bears three stout spines at its distal extremity. The inner ramus is slightly longer than the outer, and carries a strong spine about the middle of its upper margin. The distal extremities of both rami are curved upwards and very acute, and near the tip of each is a group of three delicate setæ.

Colour—Straw-yellow, with large brown markings.

Size.—Length 20 mm. Depth of pereion 3 mm.; width of pereion 3·5 mm. Depth of pleon 4 mm.; width of pleon 2·5 mm.

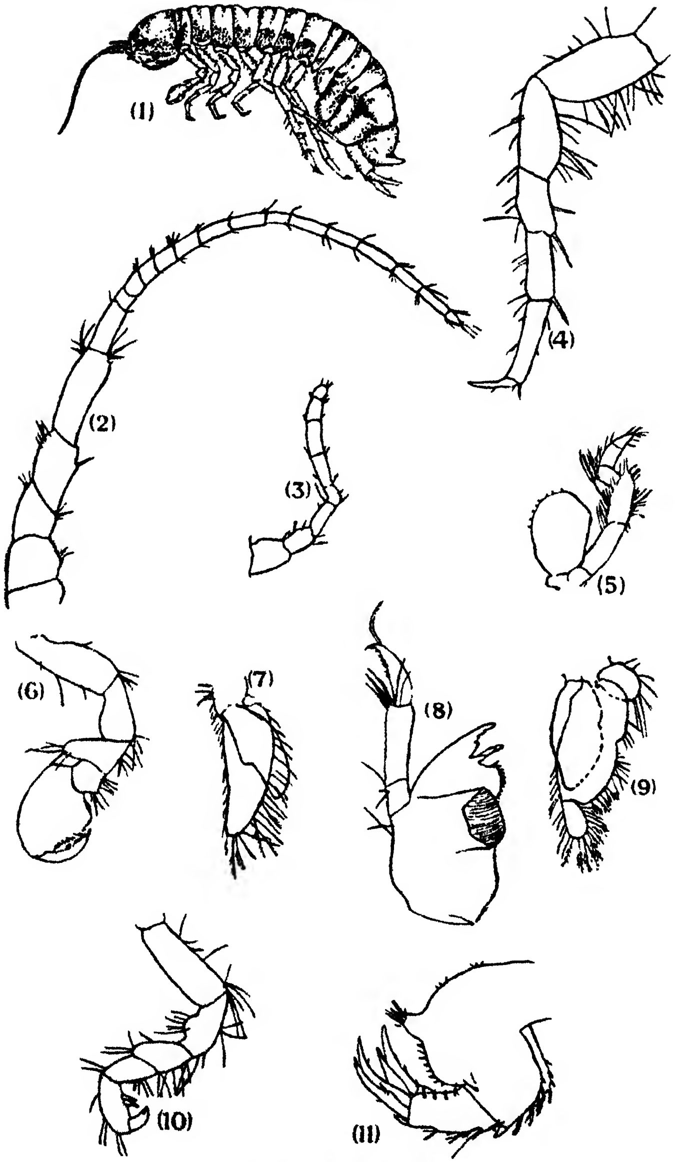
Occurrence.—In the deeper littoral zones of the Great Lake, Tasmania, where the bottom is chiefly composed of fine yellowish mud (*G. W. Smith*); also at Swan Bay and McLanagan's Bay, Great Lake (*Dr. Tattersall*).

PHREATOICUS TATTERSALLI, sp. n. (Text-fig. 6.)

Description:—

The surface of the body is slightly sculptured, and thrown into ridges which are much less prominent than those of *P. tasmaniæ* and *P. brevicaudatus*. The whole of the body is covered with small tufts of very short hairs, as well as scattered setæ which are most abundant on the dorsal surface of the telson.

Text-figure 6.



Phreatoicus tattersalli, sp. n.

(1), Adult male, × 8; (2), second antenna, × 20; (3), first antenna, × 20; (4), seventh pereiopod, × 10; (5), maxilliped, × 10; (6), first pereiopod, × 10; (7), first pleopod, × 10; (8), left mandible, × 20; (9), fifth pleopod, × 10; (10), fourth pereiopod, × 10; (11), telson and uropod, × 10.

The cephalon is about equal in length to the two following segments, and bears two laterally-placed eyes, each consisting of from 30–40 lenses. The upper antenna (text-fig. 6 (3)) consists of eight joints, a peduncle of three and a flagellum of five, and extends nearly to the end of the fifth peduncular joint of the lower antenna. The first peduncle joint is broad and covered with short thick hair; the second and third are subequal but narrower, with three or four scattered setæ. The first flagellum segment is short, a little over one-third the length of the third peduncle joint; the second is three times the length of the first, the third and fourth each a little shorter than the one preceding it, and the fifth is about one-half the length of the fourth and considerably narrower; it is tipped with four short setæ; the distal extremities of the second, third, and fourth bear two or three setæ.

The lower antenna (text-fig. 6 (2)) is nearly one-half the length of the body; it consists of a peduncle of five joints, the first two of which are covered with short hairs; the first three joints are short, the third is produced slightly on the inner side; the fourth is about equal to the second and third together; the fifth is about one and a half times as long as the fourth; the extremities of each of the 3rd, 4th, and 5th joints bear four or five setæ. The flagellum consists of sixteen joints: the first is one-half the length of the fifth peduncle joint; the second is one-third the length of the first, the length of each succeeding segment gradually increasing so that the penultimate one is about equal in length to the first; the terminal joint is one-third the length of the penultimate one and tipped with four setæ; there are several long setæ at the distal extremities of the other joints.

The mouth-parts bear a close resemblance to those described for *P. tasmaniæ*.

The left mandible (text-fig. 6 (8)) has four teeth on the incisor process and three on the lacinia mobilis; there are four teeth on the incisor process of the right mandible.

The mandibular palp consists of three joints: the first is short; the second is three times as long as the first, and bears four or five setæ at its distal extremity, the distal halves of the setæ being pectinated on one side; the third joint bears two rows of setæ, of which those of one row are simple, and those of the other row are pectinated on one side.

The extremity of the outer lobe of the first maxilla bears nine spiniform setæ, some of which are minutely denticulated, and a short distance below this a couple of plumose setæ; the inner margin of the upper half is fringed with long hairs as well as the middle and upper parts of the outer margin.

The fixed lobe of the second maxilla is not quite as long as the two articulating lobes; some of the setæ on its distal extremity are pectinate, others plumose, and others simple. The setæ on the articulated lobes are of the usual type, although the teeth are exceptionally thick.

The first pereion segment is one-half the length of the second;

the second, third, and fourth are subequal. The fifth, sixth, and seventh are slightly shorter than the fourth. The first pleon segment is about one-half the length of the last thoracic segment; the second, third, and fourth segments increase in length, each being a little longer than the one preceding it; the fifth is about twice as long as the fourth.

The pleura of the third, fourth, and fifth segments have a greater depth than that of their respective segments.

The telson (text-fig. 6 (11)), which is fused with the sixth segment, is slightly convex above, and ends in a rounded projection a little longer than broad and tipped with two spines, placed laterally, and eight longer setæ. The posterior margin below the projection is rounded and bears eight spines, the fourth of which is larger than the rest; in front of the articulation of the uropod the inferior margin is convex for a short distance, and then curves sharply upwards; it bears a large spine at its distal extremity just below the articulation of the uropod, and five longer curved spines, each of which bears two minute teeth on its upper surface near the tip.

The pereiopods (text-fig. 6 (4), (6) & (10)) and pleopods (text-fig. 6 (7) & (9)) are very similar to those of *Phreatoicus australis.* In the male the fourth pair of pereiopods is modified to form a grasping organ.

Size.—Length 10 mm.; the length of the head and pereion together is equal to that of the pleon.

Colour.—Spirit specimens; dark brown.

Occurrence.—Found under stones at Todd's Corner, on the shores of the Great Lake, Tasmania, by Dr. Tattersall.

PHREATOICUS CHILTONI, sp. n. (Text-fig. 7.)

Phreatoicus australis Smith, 1909, p. 71.

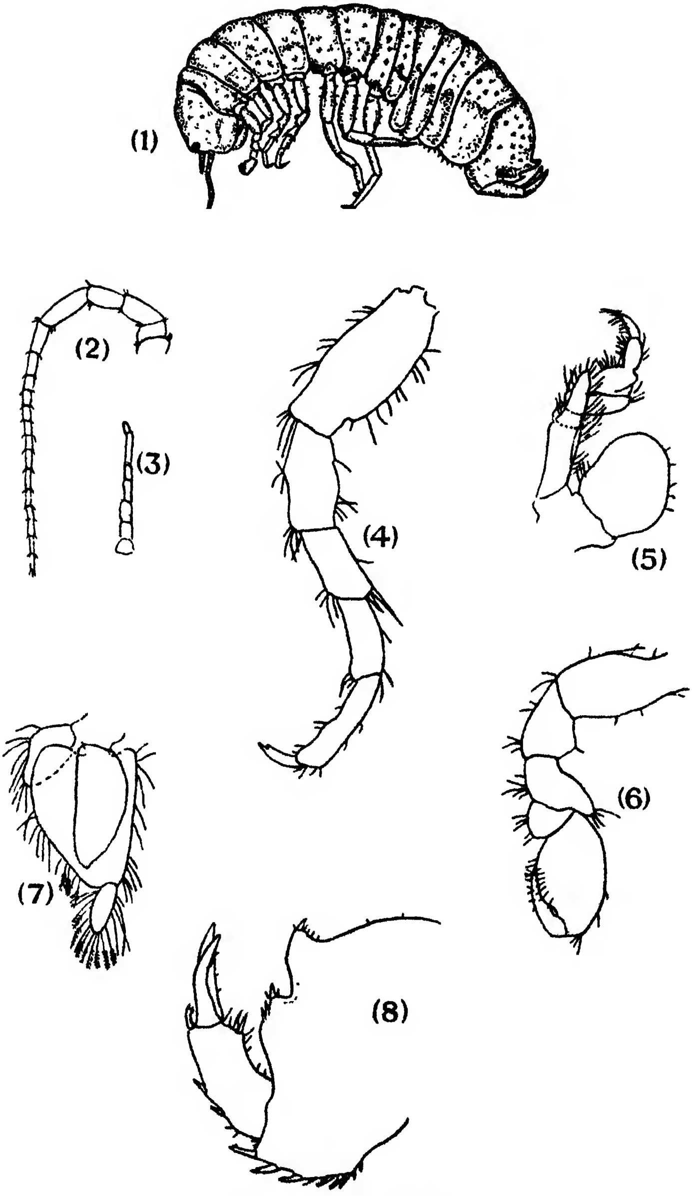
This species, the tail-piece of which was figured by Smith in his paper on "Freshwater Crustacea of Tasmania" (pl. xii. fig. 2) as a variety of *Phreatoicus australis*, has proved to differ sufficiently from that species to justify its being given a separate specific name.

Description:—

Eyes normal, of about forty lenses; the surface of the body is slightly sculptured, especially in the region of the pereion and on the telson; setæ are found only on the appendages and the margins of the pleon segments.

The upper antenna (text-fig. 7 (3)) extends a little distance beyond the fourth joint of the lower; it consists of a peduncle of three and a flagellum of four joints, the penultimate one of which is long and narrow (cf. *P. australis*) and about half as long again as the second joint, which is itself twice as long as the first; the terminal joint is about one-third the length of the penultimate one. The basal joint of the peduncle is longer than the

Text-figure 7.



Phreatoicus chiltoni, sp. n.

(1), Adult male, × 3; (2), second antenna, × 10; (3), first antenna, × 10; (4), seventh pereiopod, × 10; (5), maxilliped, × 10; (6), first pereiopod, × 10; (7), fourth pleopod, × 10; telson and uropod, × 10.

second; the second and third are subequal. The lower antenna (text-fig. 7 (2)) is one-third the length of the body; the peduncle is about one-half the length of the flagellum, which consists of fourteen joints. The first two joints of the peduncle are short, the other three are longer and subequal; the first joint of the flagellum is about one-third the length of the fifth peduncle joint; the second is a little shorter than the first and subequal with all the others; each one, however, is a little narrower than the one preceding it. Groups of setæ are present at the distal extremities of all joints, and a group is also present on the extremity of the terminal joint.

The mouth-parts are normal and very similar to those of *P. australis*; the left mandible has four teeth on its incisor process and three on the lacinia mobilis; there are four teeth on the incisor process of the right mandible. The terminal joint of the mandibular palp bears two rows of setæ; those of one row are simple, those of the other pectinate on one side. The first pereion segment is a little shorter than the second; the second, third, and fourth are subequal, with their posterior lower angles well rounded; the fifth and sixth are subequal and shorter than the fourth; the seventh is considerably shorter but deeper than the sixth.

The first pair of pereiopods is short, with a broad sub-chelate hand; the second, third, and fourth pairs are normal and well supplied with setæ; in the male the fourth pair is modified to form a grasping organ. The fifth, sixth, and seventh pairs have not got their joints expanded. (Text-fig. 7 (4) & (6).)

The first segment of the pleon is about two-thirds the length of the last pereion segment, and its pleura extend for some distance below the coxæ of the seventh pereiopods. The other segments increase in length from before backwards: the fifth is about twice as long as the fourth. The pleura are a little deeper than their respective segments: they are rounded below and sparsely fringed with setæ. The telson (text-fig. 7 (8)) ends in a small projection tipped with one large spiniform seta, curving slightly forwards, and with several smaller ones. The posterior margin beneath this projection on each side is concave for a short distance, and then curves outwards and backwards to form a second projection, which is also tipped with a stout spine; the margin beneath this is rounded and fringed with five stiff setæ. The inferior margin in front of the articulation of the uropoda is rounded, and fringed with ten stout setæ which bear four or five pectinations on their upper sides at their distal extremities; between these setæ are long, delicate, simple ones. The pleopoda are rather narrow, but otherwise like those of *Phreatoicus australis*. The basal joint of the uropod is not as stout as in *Phreatoicus australis*, and bears three groups, each of two setæ, on its under surface; its upper surface is slightly concave from before backwards as well as from side to side; each of its margins bears long setæ, which are replaced by stout spines at their distal extremities; a thick spine with several pectinations on its

upper edge is present just beneath the articulation of the rami. The inner ramus on each side is slightly longer than the outer, which curves slightly upwards and bears several groups of delicate setæ.

Size.—Length 10 mm. Head and pereion together equal to 6 mm.; pleon 4 mm.

Colour.—Spirit specimens are dark brown with light marking on the sides of the pereion segment.

Occurrence.—Found on the shores of the Great Lake, under stones and in a creek at the head of a hill, Todd's Corner, Great Lake, by Dr. Tattersall; and also in the Great Lake by G. W. Smith.

Remarks.—This species is very like *P. australis*, but differs from it in the form of the telson, the compactness of the body, the absence of expansions on the basipodites of the 5th, 6th, and 7th pairs of limbs, as well as in the length of the penultimate joints of the upper antennæ.

PHREATOICUS AUSTRALIS Chilton.

Phreatoicus australis Chilton, 1891, p. 149.
Phreatoicus australis Thomson, 1892, p. 76.
Phreatoicus australis Stebbing, 1893, p. 388.

Description:—

Eyes are normal; the surface of the body is uneven and wrinkled with shallow depressions, and with a few scattered setæ, most abundant on the last pleon segment.

The upper antenna reaches to the end of the peduncle of the lower, and consists of a peduncle of three and a flagellum of four joints, the penultimate one of which is short and broad.

The lower antenna is about one-third the length of the body, with a peduncle of five and a flagellum of thirteen joints.

There are four teeth on the incisor process and three on the accessory blade of the left mandible.

The pereion segments are more separated than those of the other species, and the basipodites of the 5th, 6th, and 7th pereiopods are expanded.

The pleura of the pleon segments are not deeper than their respective segments; they are rounded below and fringed with long setæ. The tail-piece ends posteriorly in a small narrow projection tipped with stiff setæ, two or three of which are thick and spiniform; the margin on each side below the projection is rounded and convex and fringed with six setæ, the two upper ones of which are thick and spiniform; the inferior margin in front of the articulation of the uropoda bears fifteen or sixteen short setæ, almost spiniform, most of which bear four or five pectinations on their posterior edges near the tip.

The basal joints of the uropoda are about as long as the longer rami and very stout; they each bear two groups of four or five setæ, one of which is spiniform in each group; the upper surface of the joints is broad and slightly concave, and the upper distal

angle is tipped with four strong spiniform setæ. The rami are about half the width of the basal joints; the inner one on each side is slightly the longer; both inner and outer bear stout setæ and several groups of fine ones.

Colour.—Brown and covered with marbled markings of a darker brown.

Size.—Length 13 mm. Head and pereion 9 mm. Pleon 4 mm.; depth of 4th pereion segment 1 mm.

Occurrence.—Under stones in a boggy flat, near the summit (5700 ft.) of Mt. Kosciusko, New South Wales (*Helms*); in freshwater pools on the top of Mt. Wellington (4100 ft.), Tasmania (*Thomson and Smith*); in a small stream at sea-level at Huntingfields and in a lagoon at sea-level on Bruni Island (*Smith*); in freshwater streams on Mt. Baw Baw, Victoria (*Searle*).

Figured by Chilton (1891).

PHREATOICUS CAPENSIS Barnard.

Phreatoicus capensis Barnard, 1914, p. 231.

Description:—

Eyes are well developed; the body is rather stout, with short scattered hairs.

The upper antenna consists of a peduncle of three and a flagellum of four joints, the penultimate one of which is as long as the three preceding ones together.

The lower antenna is about four-sevenths the length of the body, and consists of a peduncle of five and a flagellum of thirty joints.

The right mandible has a lacinia mobilis as well as the left.

The palm of the sub-chelate hand of the first pair of pereiopods is not well defined. All the limbs are rather slender.

The fifth pleon segment is as long as the third and fourth together, with the posterior margin notched. The telson is about twice as long as the fifth segment; it is deeply concave above the terminal projection, which is short and about as broad as long. The uropoda do not extend beyond the end of the telson.

Colour.—"Slaty-grey, with lighter crescentic mottlings on the sides of the pereion and pleon; these are large on the anterior segments, but become smaller posteriorly."

Size.—Length about 14 mm.

Occurrence.—Under moss on stones in the bog of a swiftly-running stream on the Table Mts., S. Africa, at an altitude of 3000 ft.

Figured by Barnard (1914).

PHREATOICUS TYPICUS Chilton.

Phreatoicus typicus Chilton, 1882, p. 87, and 1894, p. 279.
Phreatoicus typicus Stebbing, 1888, pp. 543 & 587.
Phreatoicus typicus Stebbing, 1893, p. 388.

Description:—

The body and appendages are rather slender. Eyes are not

developed. The upper antenna consists of eight joints, a peduncle of three and a flagellum of five, the last three joints of which are swollen.

The lower antennæ are about three-quarters the length of the body, and each consists of a peduncle of five joints, the fifth of which is twice as long as the fourth, and a long flagellum.

There are three teeth to both the incisor process and the lacinia mobilis of the left mandible. The inner lobe of the first maxilla is broad, and bears nine plumose setæ instead of the typical number of four.

The pleura of the 2nd to 5th pleon segments are not deeper than their respective segments, and are well supplied with setæ.

The projection at the extremity of the telson is longer than broad, narrowing distally, and projecting slightly upwards; its truncate extremity is tipped with rather long setæ. The inferior margin on each side, below the projection, is irregular and fringed with fine setæ. In front of the articulation of the uropoda the telson bears four curved setæ.

Colour.—Translucent.

Size.—Length rather more than 15 mm.

Occurrence.—From a pump at Eyreton in New Zealand (*Chilton*) and in walls at Ashburton (*W. W. Smith*).

Remarks.—*P. typicus* seems to bear a fairly close resemblance to *P. assimilis*, but differs from it in having a more slender body, with the pleura of the pleon segments less developed; the shape of the projection at the end of the telson is quite different in the two species.

Figured by Chilton (1882 and 1894).

PHREATOICUS KIRKII Chilton.

Phreatoicus kirkii Chilton, 1905, p. 273.

Description:—

Eyes are not developed; the body is stout and compact, the segments fitting closely; the surface of the body is curved, with a small number of slender setæ arranged singly or in tufts which are more numerous on the pleon.

The lower antennæ are scarcely one-half the length of the body; the flagellum, which consists of twelve joints, is only a little longer than the peduncle.

The mouth-parts are very similar to those of *P. assimilis*: the pereipods are rather short and bear numerous spines; the basipodites of the 5th, 6th, and 7th legs are expanded.

The pleuræ are well developed, being fully as deep as their respective segments; the fifth segment of the pleon is as long as the third and fourth together; all are thickly fringed with long setæ.

The projection at the end of the telson is longer than broad, tipped with two or three setæ and bearing several smaller ones as well; the margin below the projection on each side is irregularly convex, and bears numerous short setæ of varying degrees of

stoutness. The margin in front of the articulation of the uropoda bears six curved setæ which increase in size posteriorly.

Colour.—Whitish.

Size.—Length 17·5 mm. Depth of pereion 2 mm.; depth of pleon 3·5 mm.

Occurrence.—In a freshwater lagoon on Ruapuke Island.

Remarks.—This species, as well as its variety *P. kirkii* var. *dunedinensis*, is closely allied to the species *P. assimilis*, and, according to Chilton, may be placed in an intermediate position between it and *P. australis*.

PHREATOICUS KIRKII var. DUNEDINENSIS Chilton.

Phreatoicus kirkii Chilton, var. *dunedineneis* Chilton, 1905, p. 273.

Description :—

Eyes are not developed; this variety differs from *P. kirkii* in having the pereion segments more separated, longer, and more slender. The basipodites of the last three pairs of legs are less expanded; the other joints of the limbs are also more slender. The dorsal surface of the body bears more numerous setæ, especially the last pleon segment.

Size.—Length of body 22·5 mm.

Occurrence.—In streams at Mosgiel and Woodhaugh, near Dunedin, New Zealand.

PHREATOICUS ASSIMILIS Chilton.

Phreatoicus assimilis Chilton, 1894, p. 163.

Description .—

Eyes are not developed; the body is somewhat stout; the upper antenna consists of ten joints, the first three of which form the peduncle; the joints are thickened towards their distal ends. The lower antenna is about one-half the length of the body; the flagellum consists of about thirty joints and is considerably longer than the peduncle.

The pereiopods are rather stout, with the joints somewhat expanded; all are well supplied with setæ.

The pleura of the pleon segments are well developed, being considerably longer than their respective segments; their inferior margins are sparsely fringed with small spinules.

The projection at the end of the telson is not much produced and is broader than long; the upper angle of its extremity is sharp and tipped with a few setæ, the lower angle is rounded. The inferior margin in front of the articulation of the uropod is convex and bears four stout spiniform setæ.

Colour.—Translucent.

Size.—Length of body about 13 mm.

Occurrence.—In wells at Winchester, near Canterbury, New Zealand (*D. F. Inwood*).

Figured by Chilton (1894).

PHREATOICUS SHEPHARDI Sayce.

Phreatoicus shephardi Sayce, 1900, p. 25.

Description:—

Eyes are not developed; the body is somewhat stout, with a few scattered setæ on its surface. The upper antenna does not reach to the end of the peduncle of the lower one; it consists of a peduncle of three and a flagellum of seven segments.

The length of the lower antenna is unknown; the peduncle consists of five joints, the fifth being equal in length to the first three together.

The mouth-parts are similar to those of *P. australis*, but the outer lobe of the first maxilla is narrower and bears twelve spines. The pereiopods are spinose and the dactylus of each unguiculate. The pleura of the pleon segments are thickly fringed with long setæ. The projection at the end of the telson is only very slightly produced, and is tipped by one large median spine and two smaller lateral ones, also a few long setæ; the margin below this extremity on each side is rounded and bears one large and five small spines. In front of the articulation of the uropoda the margin on each side bears six large curved spines, increasing in size distally, and eight finer spinules near the base of the uropoda.

Colour.—Light brown.

Size.—Length 10 mm.

Occurrence.—From "amongst spongy moss at the source of a spring running into Wallaby Creek, Plenty Ranges, Victoria" (altitude about 2000 ft.).

Figured by Sayce (1900).

PHREATOICUS WIANAMATTENSIS Chilton.

Phreatoicus wianamattensis Chilton, 1918, p. 365.
Phreatoicus wiamanattensis Calman, 1918, p. 277.

Description:—

This is a fossil species bearing a general resemblance to *P. australis*. The pereion segments are deeper than long, but not more than two-thirds the depth of the pleon.

The pleura of the pleon segments are greatly produced; the 2nd, 3rd, and 4th segments are about subequal in length, but gradually increasing in depth posteriorly; the 5th pleon segment is only a little longer than the 4th.

The telson resembles fairly closely that of *P. tasmaniæ*; it is "conical in side view and ends in a subacute point with curving sides, the terminal process not being sharply defined from the general outline of the segment."

The pereiopods resemble those of *P. australis*; the first is missing in the specimens described, but the 2nd, 3rd, and 4th

are directed backwards; the basipodites of all the limbs are expanded; the joints of the 5th, 6th, and 7th limbs are longer than the corresponding ones in the anterior series.

Size.—Length to 30 mm.

Occurrence.—From the Wianamatta shales, usually classed as Trias-Jura, but probably Upper Trias, which is the nearest Australian equivalent of the Rhætic, St. Peter's Brickworks, Newtown, Sydney, New South Wales.

Figured in Proc. Roy. Soc. New South Wales (1918).

PHREATOMERUS, gen. n.

Definition:—

Body with pereion either slightly laterally compressed or with pereion not compressed, and with the pleural developments either partly or entirely concealing the basal joints of the limbs. The pleon slightly laterally compressed. The 2nd thoracic (1st pereion) segment is fused with the cephalon, but the pleural portions are free. The coxal joints of all the limbs of the male and either of all or of the 1st, 5th, 6th, and 7th in the female are fused with their respective segments; the basipodite of the 5th, 6th, and 7th limbs are expanded.

Telson truncate; epipodites are present on each of the 3rd, 4th, and 5th pleopods.

The first antenna is relatively long and tapering; there is a lacinia mobilis on the right as well as on the left mandible.

Key to the Known Species of Phreatomerus.

1.	Pleura of pereion segments 1–4 well developed, entirely concealing the coxal portions of the legs	*P. latipes* (Chilton).
	Pleura of pereion segments 1–4 only slightly developed, not entirely concealing the coxal portions of the legs.	2.
2.	Telson with mid-dorsal projection flattened and rounded	*P. palustris* (Glauert).
	Telson with mid-dorsal projection showing a median incisure	*P. lintoni* (Nicholls).

PHREATOMERUS LATIPES (Chilton).

Phreatoicus latipes Chilton, 1922, p. 23.

Description:—

Eyes well developed; body stout, with the pleural portions of the first four segments projecting outwards and slightly downwards, and completely covering the basal joints of the limbs; the pleura of the last three segments are not so well developed. The first pereion segment is fused in the middle dorsal region with the cephalon, but the lateral pleural extensions are free and produced anteriorly; the suture is well marked. The surface of the body is covered with small scattered setæ and is nearly smooth. The upper antenna is nearly half the length of the

lower one, and consists of a peduncle of three joints and a flagellum, about equal to it in length, consisting of 10 joints.

The lower antenna is a quarter of the length of the body; the flagellum of about 19 joints is equal in length to the peduncle.

The mouth-parts are very similar to those of *Phreatoicus australis*; the palp of the mandibles is short, the third joint being quite short and bent at right angles to the second, with two rows of setæ, those of one row pectinate on one side, those of the other simple; there is a lacinia mobilis to the right as well as to the left mandible; in the former there are four teeth on the incisor process and three on the accessory blade.

The inner lobe of the first maxilla bears six plumose setæ on the distal extremity (cf. *P. australis*).

The two articulating lobes of the second maxilla are slender, with nine or ten pectinate setæ of the usual type on each lobe; the fixed lobe is broader and fringed with a row of long setæ, most of which are pectinate on one side.

The first pair of pereiopods is strongly sub-chelate; the second and third are similar to one another, longer and more slender than the first pair; the dactylus of each is long and slightly curved, and when flexed forms an efficient grasping organ; the fourth pair is slightly longer than the third, and not modified to form a grasping organ.

The 5th, 6th, and 7th pairs of pereiopods have their basal joints enormously expanded into rounded lobes, which extend backwards and downwards beyond the basal joints through two-thirds the length of the ischial joints; each lobe is marked off by a distinct ridge from the joint proper.

The coxæ of all the pereiopods in the male and of the 1st, 5th, 6th, and 7th in the female are fused with body.

The pleopods differ from those of *Phreatoicus australis* in having the long plumose setæ on the exopodites replaced by less numerous short simple ones.

The depth of the pleura of the pleon segments is about equal to that of their respective segments; their lower margins are rounded and fringed with short setæ; the junction of the sixth segment, which is fused with the telson, is marked by a distinct suture. The telson terminates in a small 2 lobed projection bearing three or four setules on each half; beneath this the margin on each side is roundly convex, extending backwards and outwards beyond the terminal projection, and then curving forwards and downwards to the articulation of the uropod.

The margins below the projection bear from 12–14 short fairly stout spines; in front of the articulation of the uropoda they carry three short setæ.

The basal joints of the uropods are about equal in length to the rami, broad and concave above and fringed on both upper margins with short spines; similar spines (about nine on each) are also present on the upper surface of the rami.

Colour.—Dark slaty-grey.

Size.—Length of body 15–20 mm.; greatest breadth of body about 6·5 mm.

Occurrence.—In hot water from Maree (Hergott) bore (*Chilton*) and in springs and streams near Coward, Central Australia. Collected by Prof. F. Wood-Jones, Adelaide University.

Figured by Chilton (1922).

PHREATOMERUS PALUSTRIS (Glauert).

Phreatoicus palustris Glauert, 1924, p. 49.
Phreatoicus palustris Nicholls, 1924, p. 99.

Description :—

Eyes well developed; body rather slender, slightly laterally compressed; surface smooth, with numerous short scattered hairs; the first pereion segment is fused with the head, but the suture is distinct.

The first antenna is as long as the peduncle of the second, and consists of a peduncle of three and a flagellum of eight or nine joints. The second antenna is about three-quarters the length of the body, the fourth joint of the peduncle being as long as the first three together; the fifth is slender and as long as the second, third, and fourth combined; the flagellum is composed of from 20–23 joints.

The right mandible bears a lacinia mobilis as well as the left; there are four teeth on the incisor process and three on the lacinia mobilis of both mandibles.

The truncated ends of the two outer lobes of the second maxilla bear long pectinated setæ similar to those found in *Phreatoicus tasmaniæ*, and not "fine plumose setæ" as stated by Glauert. The fixed inner lobe is much shorter than the two outer lobes, and the setæ on its rounded tip are strong and plumose, whilst those fringing it internally to the base are long and simple.

The pleural extensions of the 5th, 6th, and 7th pereion segments completely conceal the coxal portions of the corresponding limbs. In the female the coxal joint of the 2nd, 3rd, and 4th pairs of limbs is free, whilst that of each of the 1st, 5th, 6th, and 7th limbs is fused with its segment; the suture is distinct. In the male all the coxal joints are fused with their respective segments.

The basal joint of each of the 5th, 6th, and 7th pairs of pereiopods is flat, and produced posteriorly into an oval lobe which bears an inferior notch. The fourth pair of pereiopods is not modified in the male of this species. The pleon is long and deep, equal in length to the pereion, with the fifth segment slightly shorter than the first and second together. The pleopods are normal, but have more abundant plumose setæ than the other Australian species.

The telson is "convex above, with a concavity in front of the terminal projection, convex below, with numerous spines, spinules,

and hairs, particularly on the margins." The projection forms a broad, flattened, rounded lobe. "The uropoda are long, the basal joint reaching to the end of the telson; the inner ramus is as long as the basal joint, with a pair of strong terminal spines; the outer ramus is shorter and less robust, the apex crowned with a terminal spine and several spinules and hairs."

Colour.—"Dark olive-brown, darkest on the dorsal region, which is separated on the pereion and pleon from the somewhat paler margin by a light crescentic marking on each of the segments; head marbled, flattened basis and the ischium of pereiopoda 5, 6, and 7 with pale blotches; mottlings on the other joints of the legs."

Size.—Length about 15 mm., but individuals are mature when 10 mm. in length. The breadth of a specimen 15 mm. in length is 2·5 mm.

Occurrence.—Chinamen's Garden, north end of Smith's Lake, North Perth. Collected by Glauert and K. Sheard.

Specimens I have examined were collected by Miss Fordham from swamps near the Balcatta Beach road, 5 miles from Perth.

Figured by Glauert (1924) and Nicholls (1924).

PHREATOMERUS LINTONI (Nicholls).

Phreatoicus lintoni Nicholls, 1924, p. 93.

Description:—

Eyes well developed; body moderately stout, surface smooth, with scattered hairs; the pleura of segments 1–4 slightly developed, not entirely concealing the coxal portions of the limbs. The first pereion (2nd thoracic) segment is short and fused with the head; the suture, however, is distinct.

The first antenna is relatively long, and consists of a peduncle of three and a flagellum of from 14–16 joints. The second antenna is as long as the head and first six pereion segments together, and consists of a peduncle of five and a flagellum of 27–30 joints; the first three peduncle joints are stout and subequal, the 4th is nearly as long as the 2nd and 3rd together, and the 5th, which is more slender, is nearly equal to the 3rd and 4th combined.

The mouth-parts agree in general shape with those of *Phreatoicus australis*. The right as well as the left mandible has a lacinia mobilis with three teeth; there are four teeth on the incisor process of both the right and the left mandible.

The coxal joints of all the pereiopoda are fused with their respective segments in both male and female. The "hand" of the first pereiopod is relatively small, "the sixth joint subtriangular; palm deeply concave distally, produced proximally into a densely setose prominence; dactyl scarcely shorter than propod" (*Nicholls*). The fourth pereiopod of the male is slightly modified. The basal joint of each of the 5th, 6th, and 7th limbs is expanded into a thin posterior plate, notched inferiorly. The pleon is of moderate length, slightly less than that of the pereion; the telson has

"its postero-dorsal border nearly transverse and slightly arched; the dorsal view showing a broad and shallow median incisure, bounded laterally by paired rounded prominences, each bearing a stout spine; its inferior margin produced postero-ventrally into notable spines, the most dorsal pair being particularly stout."

The pleopoda appear to be normal; the uropoda are long, with the basal joint extending beyond the end of the telson; the inner ramus is longer than the outer; both are tipped with spines.

Colour.—Dark brown; "on the dorsal surface there is a broad band of darker brown which deepens in shade towards the lateral margins to form a paired, almost black line, interrupted intersegmentally" (*Nicholls*).

Size.—Largest specimens 12–14 mm. in length: greatest breadth of pereion 3 mm.

Occurrence.—Found by Prof. Nicholls in a small sluggishly-flowing creek and adjacent swamp, draining into the estuary of the King River a short distance above the spot where that river discharges into Oyster Harbour, West Australia.

Figured by Nicholls (1924).

Genus PHREATOICOPSIS Spencer & Hall.

Phreatoicopsis Spencer & Hall, 1896, p. 12.

Definition:—

Body linear, subcylindrical: the second thoracic (1st pereion) segment is fused with the cephalon. The coxal joints of the first four pairs of pereiopods in the male and of the first pair in the female are fused with the body. The telson is truncated and horseshoe-shaped in transverse section; the uropods are short and stout, and do not project far beyond the telson. Epipodites are present on the third, fourth, and fifth pleopoda. There is only one known species belonging to the genus.

PHREATOICOPSIS TERRICOLA Spencer & Hall.

Phreatoicopsis terricola Spencer, B., & Hall, T. S., 1896, p. 12.
Phreatoicopsis terricola Raff, 1912, p. 70.

Description:—

Normal eyes are developed: the species is terrestrial. The body is stout; its surface smooth, with a few scattered short setæ. The first pereion segment is fused with the cephalon, but the line of union is clearly marked with a slight groove. The upper antenna is short, reaching to about the middle of the fourth joint of the lower; the peduncle consists of three joints, the flagellum of from 10 to 12.

The lower antenna is about one-third of the length of the body; the peduncle of five joints is longer than the flagellum, which consists of from 27–37 short joints; the 4th and 5th peduncle joints are long and subequal.

The mouth-parts bear a fairly close resemblance to *Phreatoicus australis*; the left mandible has three teeth on both its cutting edges, and the right mandible has a lacinia mobilis as well as the left; it has four teeth on its primary and two on its accessory blade.

The mandibular palp consists of three joints, the distal one of which bears three long setæ on its extremity.

The inner lobe of the first maxilla is smaller than the outer, and forms a narrow flattened lobe, rounded distally and having setæ arranged in two rows—an outer one of short stout setæ doubly pectinate at their distal extremities, and an inner one of longer plumose setæ. The two articulating lobes of the second maxilla are very slender and terminate in two pectinate spines; both lobes bear a large number of pectinate setæ of varying lengths, which are more numerous on the inner than the outer lobe.

The coxal joints of the first four pairs of limbs in the male and of the first pair in the female are fused with the body, the lines of union having partly disappeared; the coxal joints of the 5th, 6th, and 7th pairs are free in both sexes.

The pereiopods agree in general with those of *Phreatoicus australis*, but setæ are not so numerous and are short and strong. The 4th pair in the male is not modified.

The pleura of the 2nd, 3rd, 4th, and 5th segments of the pleon are equal in depth to their respective segments.

The 6th segment is completely fused with the telson to form a tail-piece, which is horseshoe-shaped in transverse section; its posterior end, which is bordered by strong spinose setæ of varying lengths, is truncate and gapes widely. The exopodites of the pleopods bear long simple setæ (cf. *P. australis*).

The uropods do not project beyond the telson; the basal joint is as long as the longer of the two rami and very stout; its upper surface "is broad and concave, and its inner angle is produced into a well-marked process terminating in a strong spinose seta." The inner ramus is considerably longer than the outer; both are strong and curved upwards.

Colour.—Creamy-white.

Size.—Length 45 mm.

Occurrence.—Found burrowing in the earth, on hills in a dense forest overlooking the Gellibrand River, 20 miles south of Colac, Victoria (*W. H. F. Hill*); from Otway Forest (*H. P. C. Ashworth*); from Mt. William, near Ararat (*A. A. Kitson*); and from the Grampians (*W. H. Ferguson*).

Figured by Spencer and Hall (1896).

Genus Phreatoicoides Sayce.

Phreatoicoides Sayce, 1900, p. 122.
Hyperœdesipus Nicholls & Milner.

Definition:—

Body linear, subcylindrical; the second thoracic (1st pereion)

segment distinct and movably articulated with the head. The last six pairs of coxal joints are articulated with the respective pereion segments; the pleon is relatively short and slightly laterally compressed; the segments are not produced and the pleopoda are exposed. Epipodites are absent from the third, fourth, and fifth pleopoda.

The telson is large and truncate, and is attached to the long preceding segment by a narrow joint.

Key to the Known Species of Phreatoicoides.

Pleopoda are fringed with long plumose setæ	*P. plumosus* (Nicholls & Milner).
Pleopoda less well developed, and sparsely fringed with short setæ.	*P. gracilis* (Sayce).

PHREATOICOIDES PLUMOSUS (Nicholls & Milner).

Hyperœdesipus plumosus Nicholls & Milner, 1923, p. 23.

Description:—

Eyes not developed; body slender, slightly compressed; surface smooth, with sparsely-scattered setæ. Cephalon is much longer, slightly deeper and somewhat wider than the following segment. The first pereion (2nd thoracic) segment is about half as long as the second; the 5th, 6th, and 7th are each shorter than the fourth. The pleura of the pleon segments are scarcely developed; segments 1–4 are short, but the fifth is about twice as long as the preceding one and is joined to the large telson by a narrow "neck."

The first antenna is short, not reaching to the distal end of the peduncle of the second; it consists of a peduncle of three and a flagellum of five or six joints, the penultimate one of which is longer and broader than any of the others; the terminal joint is short and bears a tuft of fine setæ.

The second antenna is about half the length of the body; it consists of a peduncle of five and a flagellum of from 21–27 joints. The first joint of the flagellum is twice as long as the succeeding one.

The mouth-parts agree in general shape with those of *Phreatoicoides gracilis*. There are four teeth on the incisor process of both mandibles as well as on the lacinia mobilis of the left; the right mandible does not bear a lacinia mobilis.

The outer lobe of the first maxilla is shorter and stouter than the inner, with its truncate extremity fringed with short curved setæ; the inner lobe bears four plumose and a number of simple setæ on its rounded extremity.

The maxillipeds are large and similar to those of *P. gracilis*; the epipodite, however, does not extend as far as the distal end of the ischium, and the dactyl is rather swollen, with both its inner and outer margins convex.

The pereiopoda are long and slender, with their coxal joints

distinct. The first pair of pereiopoda are sub-chelate, and, in the mature male, the propod is large and of a characteristic shape which is unlike that of any other known Phreatoicidæ. "Its anterior margin is produced upwards, almost vertically, and stretches proximally more than half the length of the ischium, forming a large swelling on the anterior border of the propod. At its proximal end the posterior margin is convex and bears numerous stiff spiniform setæ; distally its outline is concave, and this part of the palm is almost bare of setæ. The dactyl is actually longer than the propod, but much narrower and curves slightly inwards to terminate in a strong claw-like spine" (*Nicholls and Milner*).

In the female the swelling on the anterior margin is absent, the palm is "more sparsely setose," and the dactyl is shorter. The fourth pereiopod of the male is modified to form a grasping organ.

The pleopoda are large and well developed; they are exposed and are fringed with long plumose setæ. The endopodite decreases in size from before backwards, so that, on the fifth pleopod, it is only about a third of the length of the exopodite.

The telson is large and truncate, over half the length of the pleon segments; its postero-dorsal margin is convex and, according to Nicholls and Milner, "deeply notched in the middle line"; this notch, however, is not apparent in my specimen. Posteriorly to insertion of the uropods the convex inferior margin curves upwards to meet the short posterior margin.

The uropoda are well developed; the peduncle extends to beyond the end of the telson; the outer ramus is two-thirds the length of the peduncle, and ends in an acute point, with numerous spiniform setæ; the inner ramus is slightly longer and thicker than the outer, and curves inwards.

Colour.—Whitish, translucent.

Size.—Length about 10 mm.; a mature female measured 6 mm.

Occurrence.—"Found sparingly in a pool of a square yard or less in extent, fed by a spring and situated just at the foot of the Lesmurdie Falls, in the Darling Range, W.A." (*Nicholls*).

Figured by Nicholls and Milner (1923).

PHREATOICOIDES GRACILIS Sayce.

Phreatoicoides gracilis Sayce, 1900, p. 122.
Phreatoicoides gracilis Sayce, 1901, p. 558.

Description :—

Eyes are not developed; the cephalon is longer than the following segment and also deeper and somewhat wider.

The body is slender and greatly elongated, with long setæ scattered sparsely over its surface.

The upper antenna does not extend to the end of the peduncle of the lower one, and consists of a peduncle of three and a flagellum of six or seven joints.

The lower antenna is about two-thirds the length of the body; the fifth peduncle joint is as long as the first three together; the flagellum consists of 28 joints.

The distal extremity of the outer lobe of the first maxilla bears nine spiniform setæ; that of the inner lobe is rounded, and bears three plumose setæ as well as two short spines near its inner margin.

The left mandible has four teeth on both the incisor process and the lacinia mobilis, but those on the latter are smaller.

The pereiopods are long and slender; the coxæ are distinct.

The pleura of the pleon segments are not produced; their inferior margins are sparsely fringed with small spinules. The 5th segment is as long as the three preceding ones together, and is united to the telson by a narrow neck. The telson is large and powerful: its posterior distal angle is not produced, but is tipped with several setæ; the posterior margin above the articulation of the uropoda is irregularly convex, and the inferior margin in front of the articulation is slightly notched, but free from setæ or spines. The uropoda extend for a short distance beyond the telson; the basal joint is broad and about equal in length to the rami, which are narrow, curved slightly upwards, and tipped with setæ. The first and second pairs of pleopods (text-fig. 2 (6) & (7)) are very similar to those of *Phreatoicus* species, but are sparsely fringed with short setæ; the 3rd, 4th, and 5th pairs are all similar to each other, but decrease in size from before backwards. The exopodite of each is broad in comparison to its length, with the 2nd joint attached some distance from the distal extremity of the first and hardly projecting beyond it: both joints bear a few short setæ. The endopodite of each is very much reduced in size, that of the last pair (text-fig. 2 (9)) being considerably smaller than the "epipodites," which are absent in this genus, but are found on the 3rd, 4th, and 5th pairs of pleopods of other members of this order. It is probable that the degenerate form of the pleopods and the absence of the "epipodites" is correlated with the absence of pleura on the pleon segments and the consequent lack of protection.

Colour.—Creamy-white.

Size.—Length 9–20 mm.

Occurrence.—In a freshwater tunnel in a small tributary of the Narracan, Thorpdale, Gippsland.

Figured by Sayce (1900).

Genus Hypsimetopus Sayce.

Hypsimetopus Sayce, 1902, p. 218.

Definition:—

Body subcylindrical; cephalon relatively larger, being higher in

front and also deeper than the following segment, with which it freely articulates; the first pereion segment is about as long as the succeeding one, with its antero-lateral corners produced forwards.

The pleon is relatively short, the pleura are only slightly produced, and the pleopoda are almost entirely exposed.

Epipodites are present on each of the 3rd, 4th, and 5th pairs of pleopods. Last six pairs of coxal joints are articulated with the respective pereion segments.

The sub-chelate hand of the first appendage in the male is enormously developed.

There is only one known species belonging to this genus.

HYPSIMETOPUS INTRUSOR Sayce.

Hypsimetopus intrusor Sayce, 1902, p. 218.

Description :—

Eyes are not developed; the body is rather slender and the surface smooth.

The upper antenna does not reach to the extremity of the fourth joint of the lower one: it consists of a peduncle of three and a flagellum of seven joints.

The length of the lower antenna is unknown; the peduncle is long and the fifth joint is longer than the fourth.

The mouth-parts are fairly normal; the left mandible has four teeth on the incisor process and three on the accessory blade.

The inner lobe of the first maxilla is shorter than the outer: its distal extremity is very oblique, with a "single spine at its outer extremity, at the base of which arises a long plumose seta, then a row of five stout setæ slightly curved, and a little pectinated near the ends on their outer faces and ciliated along the same face lower down."

The first four pereion segments are subequal in length, and the last three are subequal, but shorter than the first four.

The pereiopods are rather slender, excepting the first of the male, which has an enormous sub-chelate hand which is "subtriangular, narrow at the insertion of the finger; palm oblique, concave; margin entire, and fringed with long spiniform setæ, meeting the posterior border in a clearly-defined obtuse angle; the anterior and posterior margins are evenly convex. The finger is a little shorter than the palm, impinging against the inner side of the hand beyond the palmar edge; its inner surface, near the middle, is tumified."

The fourth pereiopod shows no modification in the male.

The pleon is only a little deeper than the pereion.

The telson, which is fused with the sixth segment, narrows somewhat distally, and is constricted above to form a small truncated projection, which is almost hidden in lateral view; this bears on its upper surface two transversely-placed stout spines

and numerous long setæ, and below the projection on each side is a stout spine; the margin curves downwards and forwards to the base of the uropoda, and is fringed by a stout spine, several spinules, and setæ.

The margin on each side in front of the articulation of the uropoda curves evenly upwards and bears two stout and four simple spines.

The pleopods are normal, sparsely fringed with short setæ; a few at the distal extremities are plumose.

The basal joint of the uropod is longer than the rami, the inner of which is slightly the longer.

Colour.—Spirit specimens; creamy-white.

Size.—Length of male specimen 15·5 mm.

Occurrence.—In burrows of the Land Crayfish (*Engæus cunicularius*), near Zeehan, Tasmania (*Haswell*).

Figured by Sayce (1902).

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6. The External Characters of the South African Striped Weasel (*Pœcilogale albinucha*). By R. I. Pocock, F.R.S., F.Z.S.

[Received November 15, 1926 : Read February 22, 1927.]

(Text-figures 1–5.)

Setting aside the Otters, the family Mustelidæ is represented in South Africa by three genera only—*Mellivora*, *Ictonyx*, and *Pœcilogale*. *Mellivora* and *Ictonyx* cannot be closely affiliated with any genera found elsewhere in the world; and in my paper, "The External Characters of the Mustelidæ" (Proc. Zool. Soc. 1921, pt. iv. pp. 803–837), I regarded them as the types of two subfamilies, Mellivorinæ and Ictonychinæ. At that time *Pœcilogale albinucha* was known to me, so far as its external characters are concerned, only from dried skins; and the genus was tentatively and quite provisionally referred to the Ictonychinæ. Since then I have seen two subadult examples, preserved in alcohol, in the British Museum; and this paper is based upon an examination of those specimens.

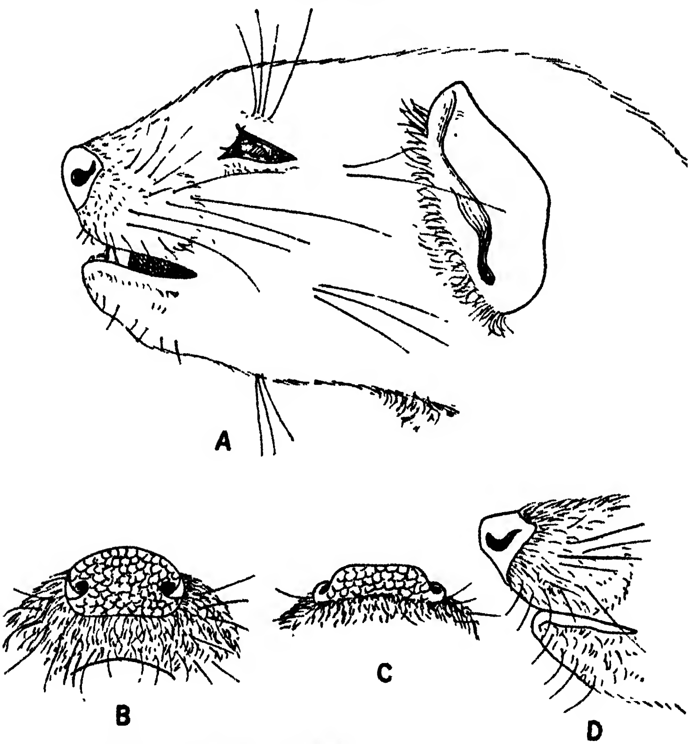
Gray, it may be added, originally assigned the species to the genus *Ictonyx*, then known as *Zorilla*. In its style of colouring it somewhat resembles the Zorillas, being black with four white stripes extending along the back; but these fuse in front with a white cap covering the top of the head and the nape of the neck. Posteriorly they pass on to the tail, which is tolerably long, but less bushy than in the Zorillas. But in general build *Pœcilogale* is unlike the Zorillas, the head being short, with a blunt snout, and the body very long and slender as in typical Weasels. The Zorillas in build are more like Skunks, though more elegant, and the snout is longer than in *Pœcilogale* and more adapted for probing. (Text-fig. 1, A & D, p. 126.)

The *palate* in *Pœcilogale* is remarkable for the large size and reduction in the number of its ridges, of which there are but four on each side. The anterior is a crescentically-curved ridge, with convex anterior border and concave posterior border. It is gradually thickened towards the middle line, where it abuts against the median incisors, its thinner extremities rising close to the canines. This is the only ridge which is continuous across the middle line. The others are divided mesially, and consist of a right and left portion. Their outer ends are situated near the two premolars and the molar. They are thick, but become progressively shorter from before backwards, those whose outer ends are close to the antero-internal angle of the anterior premolar being about twice as long as those between the molars. They are directed inwards and forwards towards the middle line, the

anterior pair of the three extending so far forwards as to be only a little behind the ridge above described between the canines. (Text-fig. 2 C. p. 127.)

In the reduction in number and the thickness of these ridges the palate of *Pœcilogale* differs remarkably from that of *Mustela erminea* and *putorius*, described and figured recently in my paper on *Lyncodon* (Proc. Zool. Soc. 1926, p. 1088, text-fig. 52, B). It is

Text-figure 1.



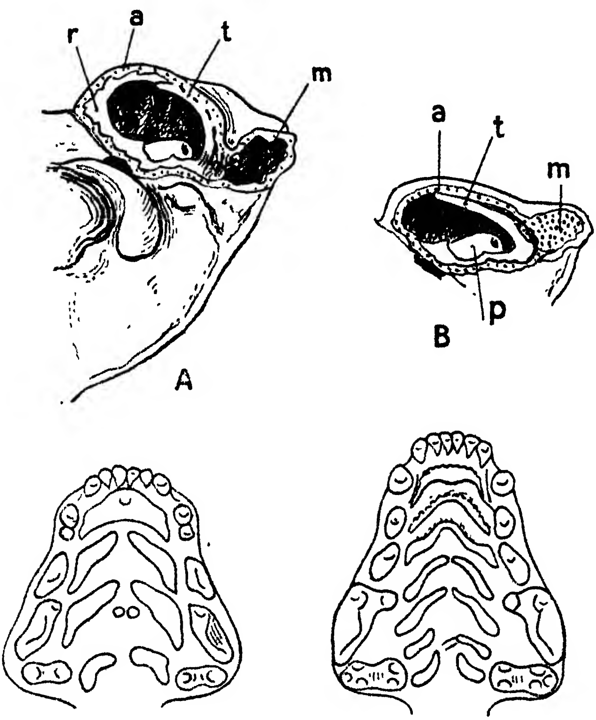
A. Head of *Pœcilogale albinucha*.
B. Rhinarium of the same from the front.
C. The same from above.
D. Side view of muzzle of the Egyptian Zorilla (*Pœciliotis lybica*).

interesting to note, too, that although *Lyncodon* resembles *Pœcilogale* in the reduction in number of the cheek-teeth, there is no corresponding reduction in the number of the palatal ridges as there is in *Pœcilogale*. The palate of the Zorillas is also unlike that of *Pœcilogale*, and more resembles the palate of *Mustela* and *Lyncodon* in the number of its ridges, although there is a reduction in the number of the smaller posterior ridges. (Text-fig. 2, D, p. 127.)

The *tongue* is similar in its spicules to that of the typical Weasels and Zorillas.

The *facial vibrissæ* of *Pæcilogale* are normal for the family in the number and position of the tufts, but are all comparatively

Text-figure 2.



A. Posterior view of the left half of the occipital region, with the bulla cut open, of *Pæcilogale albinucha*, showing the hollowed mastoid opening into the cavity of the bulla which is subdivided by bony rafters and ridges.

B. Bulla of an immature specimen of the same showing the solid mastoid and the absence of bony ridges in the cavity of the bulla.

C. Palate of young *Pæcilogale*.

D. The same of *Pæcilictis*.

a. cut edge of bulla; *r*. rafter; *t*. tympanic bone; *m*. mastoid; *p*. pefrous portion of periotic.

short, the genals being hard to detect amongst the normal hairs of the cheek. None of the mystacials reach posteriorly as far as the ear. The superciliary tuft consists of four bristles: the upper genal of two, set, as in most Mustelidæ, high up behind the

posterior angle of the eye; the lower genal of about three, set beneath the upper and in line with the mouth; and the interramal of about three bristles; there are also a few inconspicuous submentals. (Text-fig. 1, A, p. 126.)

The *rhinarium* is areolated throughout. Viewed from above it appears as a short, transverse, nearly parallel-sided area with straight anterior and concave posterior border and rounded angles, the hairs from the muzzle advancing farther over it in the middle than laterally, where it does not quite reach the notch of the nostrils. In profile its edge is lightly convex from above downwards. Seen from the front it is about twice as wide as deep; its upper border is lightly convex in the middle, more strongly convex at the sides; its lower border is nearly straight, without trace of median angle; there is no median groove and the nostrils are widely separated. The area of the upper lip beneath it is shallower than the rhinarium and is entirely undivided, being continuously hairy across the middle line, without trace of philtrum. (Text-fig. 1, B, C, p. 126.)

In general form, the absence of the philtrum, and widely-separated nostrils the rhinarium shows considerable likeness to that of *Plesiogale nudipes* from Sumatra (Proc. Zool. Soc. 1921, pt. iv. text-fig. 27, E); but in the latter the rhinarium has the upper part of its anterior surface mesially grooved and the upper margin biconvex, with a median angular notch.

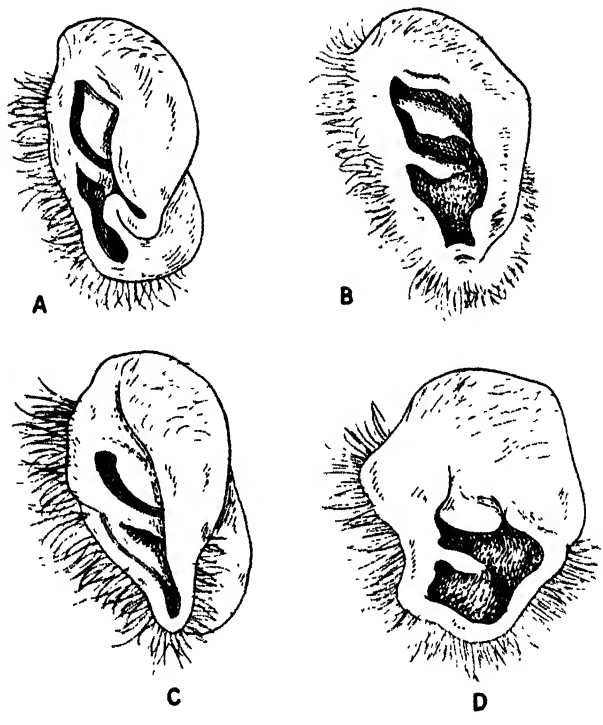
The *ear* is reduced in complexity and size as compared with that of *Mustela*. It is smaller, and there is no trace of the bursa on the narrow laminate area of the pinna behind the cavity. The supratragus is tolerably well developed and valvular, with its free border convex or bilobate. Above it the upper edge of the cavity exhibits a narrow longitudinal flap, such as is common in *Mustela* and other predatory members of the family; and below the supratragus there is a very definite longitudinal ridge jutting into the cavity and rising in front from the anterior edge of the cavity. This ridge fuses with the thickening partially filling the lower part of the cavity containing the auditory orifice, which is set just within the intertragal notch or *inferior aditus*. This notch is bordered in front by a high but shallow tragal lobe and behind by a lower but more pronounced antitragal lobe. (Text-fig. 3, A, B, p. 129.)

The Zorillas (*Ictonyx* and *Pœcilictis*) also have less complex ears than *Mustela*, the bursa being entirely suppressed; but the upper part of the pinna is larger and more laminate than in *Pœcilogale*, and the supratragus is somewhat smaller. There also appears to be a difference between *Pœcilictis* and *Pœcilogale* in the way the ear is closed. In both the posterior portion moves forwards, the supratragus and the ridge beneath it assuming an oblique or nearly vertical position, the antitragus being applied to the tragus, and the posterior margin of the cavity to the anterior. But whereas in *Pœcilictis* the antitragal area

remains straight, in *Pœcilogale* it is very definitely folded on itself. (Text-fig. 3, C, D.)

In the structure of the *auditory bulla*, which I previously described from an imperfect specimen, *Pœcilogale* is more like *Ictonyx* or *Pœcilictis* than *Mustela*. As in *Ictonyx*, the cavity of the bulla, which is undivided by a partition but has many rafters

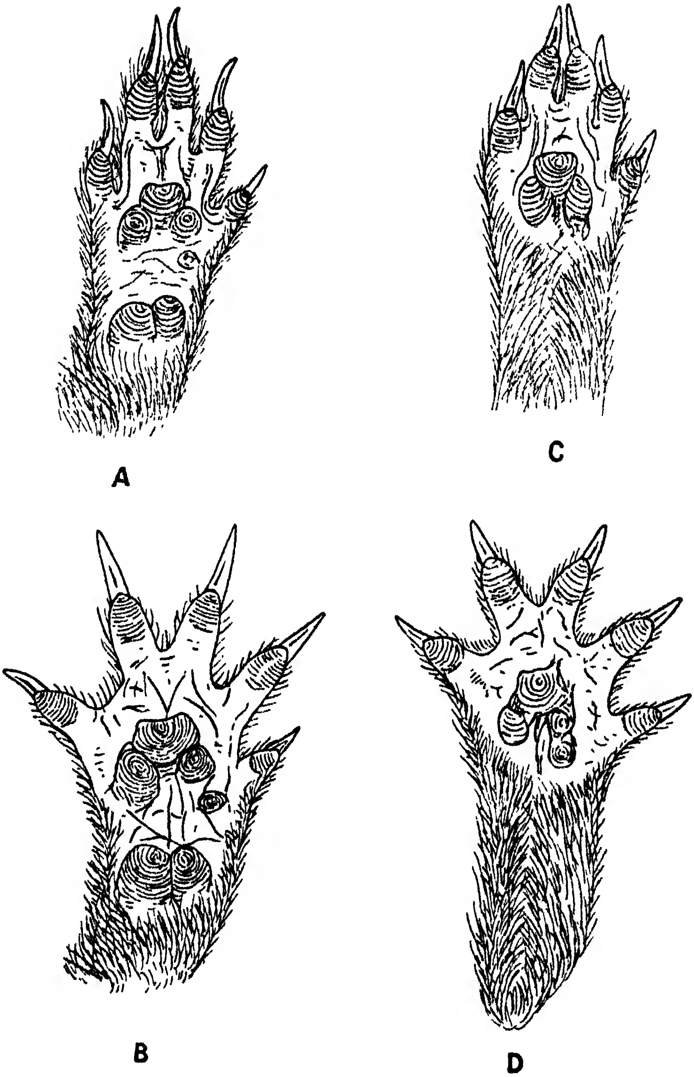
Text-figure 3.



A. Ear of *Pœcilogale*, partly folded.
B. The same expanded.
C. Ear of *Pœcilictis*, partly folded.
D. The same expanded.

on its roof and sides, and anastomosing ridges on its floor, communicates posteriorly with the hollowed mastoid portion of the periotic in the adult; and the roof of the bulla is not composed of thick and spongy bone as in *Mustela*. But, as in *Mustela*, the tympanic ring is in contact with the roof of the bulla. In one immature example the cavity of the bulla is undivided by trabeculæ, the floor is not broken up by anastomosing

Text-figure 4.



A. Right fore foot of *Pœcilogale*, with digits closed.
B. The same of another specimen with digits expanded.
C. Right hind foot of *Pœcilogale* with digits closed.
D. The same of another specimen with digits expanded.

ridges as in the adult, and the cavity does not extend into the mastoid. (Text-fig. 2, A, B, p. 127.)

The *fore feet* have moderately long claws. The 3rd and 4th digits are symmetrically paired and susceptible of comparatively slight separation; but the web between them does not extend up to the digital pads. They are more closely united than the 3rd is to the 2nd or the 4th to the 5th. All the digits are separated by comparatively deep interdigital spaces, the webbing being poorly developed. The 2nd digit is a little in advance of the 5th, and the 5th is in advance of the 1st. The digital pads are transversely striate. The plantar pad is well developed and four-lobed, although the rounded pollical element is isolated from the rest. The remaining three lobes are widely in contact, the median being nearly as large as the other two combined, and the inner smaller than the outer. All the elements of this pad are concentrically striate. The entire area round the plantar pad is, like the underside of the digits, covered with naked, wrinkled skin. There are two large concentrically striate carpal pads in contact throughout their length and together almost equalling the plantar pad in size. The hairs of the carpus extend down to their posterior border. The carpal vibrissæ are exceedingly short, and scarcely perceptible amongst the normal hairs of the carpus. (Text-fig. 4, A, B, p. 130.)

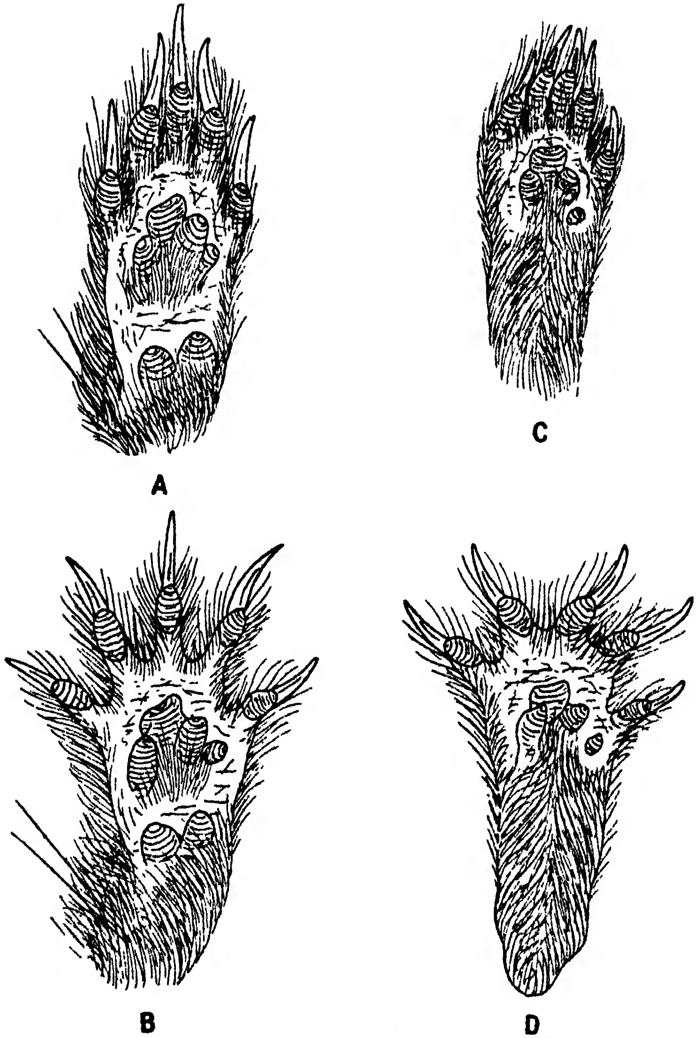
The fore foot resembles that of the typically cursorial or semi-arboreal Mustelidæ in being artiodactyle, *i. e.* in the symmetrical pairing of the 3rd and 4th digits. The claws, however, are longer and the webbing between the digits much less extensive, this being especially noticeable between the 3rd and 4th digits. In the nakedness of the sole, as also in the development of the plantar and carpal pads, this foot more closely resembles that of *Plesiogale nudipes* than of any member of the Mustelinæ known to me (*loc. cit.* p. 819, text-fig. 33, A, B); but the inner carpal pad in *P. nudipes* is relatively much smaller.

The fore foot of *Ictonyx* and *Pœcilictis* is more typically fossorial in character, the claws being long and strong; and in its natural position the foot is perissodactyle, the 3rd digit lying in the middle line. Moreover, the sole of the foot is generally at all events partially hairy in *Ictonyx*; and although the plantar and carpal pads vary in the size of their lobes, they are never so symmetrical as in *Pœcilogale*. (Text-fig. 5, A, B, p. 132.)

The *hind foot* is a little narrower than the fore foot, but in the nakedness of the area round the plantar pad and of the under-side of the digits, the disposition and proportion of the digits, the striation of the pads, and the size of the plantar pad it is very similar. The hallucal lobe of the plantar pad is, however, in contact with the inner of the three main lobes of the plantar pad and lies behind it; and there is a deep groove behind the median lobe separating the inner and outer lobes. There is no trace of metatarsal pads, the metatarsal area being continuously hairy from the heel nearly down to the plantar pad. (Text-fig. 4, C, D, p. 130.)

This foot also is Musteline rather than Zorilline. It is larger

Text-figure 5.



A. Right fore foot of *Pœcilictis* with digits closed.
B. The same with digits expanded.
C. Right hind foot of the same with digits closed.
D. The same with digits expanded.

in proportion to the fore foot than in *Pœcilictis*, and in the latter the digital pads 2, 3, 4, and 5 form a much more evenly-curved series and the webs are deeper. (Text-fig. 5, C, D.)

In the *anus* and *external genitalia* there is nothing special to note. The specimens are young and there is no trace of a scrotum, the testes being small and inguinal. The whole area is continuously hairy, except immediately round the anus, where the skin is naked. The orifices of the anal glands lie just within the anal aperture, and the glands themselves are moderately well developed; but they are not sufficiently large to suggest the secretion of an unusual quantity of nauseating fluid. So far as I am aware, there is no evidence that this Weasel is protected by its secretion as is Zorilla. At all events, Mr. Fitzsimons, who kept them alive at various times, says nothing about objectionable qualities in them. Hence the general likeness in coloration between *Pœcilogale* and *Ictonyx* may very likely be an instance of true or Batesian mimicry, as I suggested in my paper on the warning characters of Musteline Carnivora (Proc. Zool. Soc. 1908, p. 948).

7. On the Structures of the Hard Palate of *Felis tigris*. By Chi Ping, Department of Zoology, University of Amoy, Amoy, China *.

[Received June 18, 1926: Read February 8, 1927.]

(Text-figures 1–3.)

On December 13, 1925, news was received of the appearance of a tiger in the hills of Nan Pu-toa, in Amoy. It was supposed to have come from the mountains of Nan Tai Wu, about five miles from the Amoy Island across the bay, reaching the latter place by swimming over. Three days later it was shot by police and brought to the court for exhibition. President Lim Boon Keng, of the University of Amoy, secured the skeleton for the University Museum. I had the pleasure of making some observations on some of the soft structures of the hard palate left with the skull. Unfortunately, as the specimen was cut into pieces and the soft parts were removed by people at the police court, I regret that I missed the opportunity of observing the body weight, length, and the external and internal characters. According to the general features of the skin, which my assistants mounted for the police court as a souvenir, it is a Bengal tiger. It is a male, old and probably sick, as shown by its skeleton and skin, and after being mounted its body-length measures 182 cm., but its tail-length is not obtainable, as a great deal of its distal portion was lost. The occurrence of this species of tiger in South China has been reported by Robert Swinhoe, 1870 †.

The general shape of the hard palate, as shown in text-fig. 1, is elongate ovoid, measuring 142 mm. along the middle line, 49 mm. wide between the extremities of the first ridge, and 89 mm. between those of the seventh. It resembles very largely the general appearance of the hard palate of the domestic cat. In the case of the cat's palate there are eight ridges, but usually the first one is not distinct. On the tiger specimen I find altogether eleven ridges both long and short, all of which are very distinct. In the usual manner, at the middle of the first ridge there is a large papilla, which is ovoid, measuring 9·5 mm. cephalo-caudad and 10 mm. laterad. It extends caudad, coming into contact with the second ridge. Caudad to the last, or eleventh ridge, is another large papilla, which measures 3 mm. cephalo-caudad and 3·5 mm. laterad, whose cephalic border is not distinct but whose caudal border is bounded by a small transverse furrow. This papilla is not found on the hard palate of the cat. With the exception of the last three ridges between each consecutive two the transverse

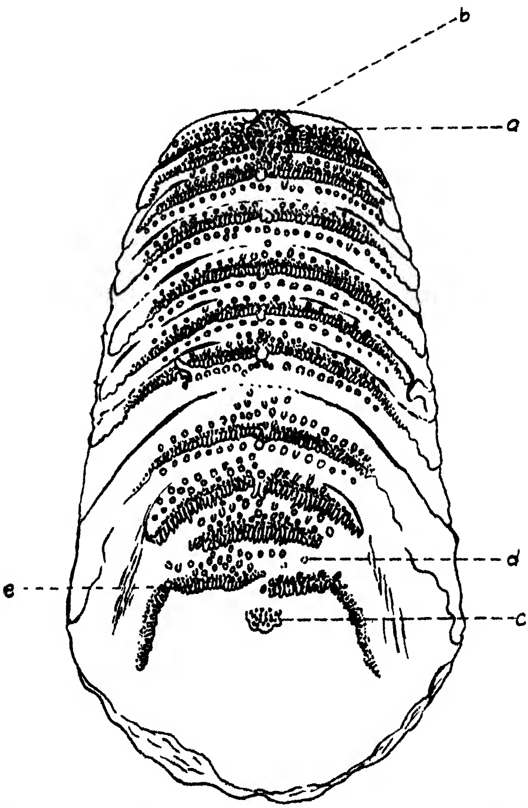
* Communicated by the Secretary.

† R. Swinhoe, 1870. Exhibition of, and remarks upon, a skin of a Manchurian Tiger and Chinese Leopard. P.Z.S. p. 4.

furrow is distinct, especially towards both sides of the palate. The most pronounced ones are those between the sixth and seventh and between the seventh and eighth ridges.

Turning to the more minute structure, there are some interesting features worth recording. On the surface of the anterior large papillæ are numerous minute tubercles, most of

Text-figure 1.



Surface view of the hard palate. *a*, minute pimples; *b*, anterior large papilla; *c*, posterior large papilla; *d*, indistinct papilla; *e*, notch.

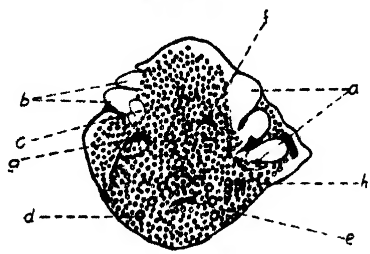
which are rounded, and among them are three or more slightly larger ones near each latero-caudal margin. They are definite and regular in shape and can be readily recognized with the naked eye (text-fig. 2). At each cephalo-lateral margin are three or more still larger ones whose shapes are irregular; some of these are almost fused with one another. Irregular depressions are found

lateral to the middle line, and a much larger one situated close to the left margin. The middle portion of the left margin is more angular and projected laterally more than the right one.

On each side of the large papilla are found minute tubercles, which are hardly visible without the aid of a lens. They cover the entire surface between the anterior margin of the hard palate and the edge of the first ridge, forming the background for the other papillæ. The latter are largely rounded in shape, and their numbers on each side of the anterior large papilla are not equal, neither is their distribution symmetrical. Minute tubercles are distributed on the sloping surfaces of all the remaining ridges, but are not found in spaces between them.

The first ridge is broken in the middle line owing to the caudal extension of the interior large papilla. A few papillæ are crowded latero-caudal to the latter structure. Between the first and second ridge there is one row of papillæ. Their general shape and size are somewhat similar to those cephalic to the edge of

Text-figure 2.



Surface view of the anterior large papilla. *a*, *b*, *c*, and *d*, larger tubercles; *e*, *f*, and *g*, depressions; *h*, minute tubercles.

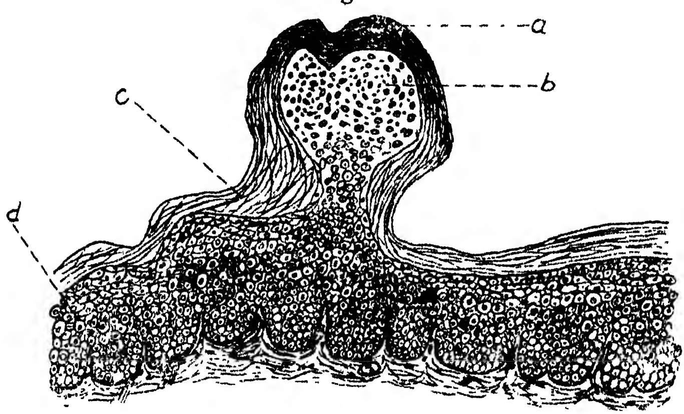
the first ridge. Between the second and third ridge, the papillæ tend to be arranged into two rows towards the lateral portions of the palate, but in the middle they are more or less crowded. From the third to the ninth inclusive, the arrangement of papillæ between each two consecutive ridges is always in two distinct rows, but between the sixth and the seventh and between the eighth and the ninth there are a few papillæ occupying the middle region of the spaces between those in the rows. On account of the close approach to each other of the ninth and tenth ridges, the rows of papillæ between them are not distinct. The same state of affairs is found between the tenth and eleventh ridges, and, moreover, most of the papillæ on the left portion are not distinct and practically disappear, thus making their arrangement in this region of the palate asymmetrical.

The shape of the papillæ in these rows between the ridges varies to a certain extent. It will be noticed that a great many of them are nipple-shaped, some are conical, some pyriform, some

compressed cephalo-caudad, and very few bi-lobed. A number of them have tips of reddish-brown colour, due to pigmentation, and practically all of them are covered with minute tubercles. The distribution of the papillæ in these rows is in accordance with size but not with shape. The larger ones are always found in the middle region. The size of the papillæ decreases towards the lateral portion of the palate. The largest one in each row measures on the average 2 mm. wide and 2 mm. long.

The edge of each ridge consists of comparatively small-sized papillæ in great number. They are closely packed, side by side, making the edge of each ridge pectinate. On the first ridge most of them are more or less fused to one another, but on the other ridges they are distinct, their tips being slightly depressed

Text-figure 3.



Cross-section of the stratified squamous epithelium with a larger papilla of the sixth ridge. *a*, chitinized capsule; *b*, concentric arrangement of cells; *c*, cornified layer; *d*, cell-bridges.

dorso-ventrad into blunt lobes. The papillæ of the ninth ridge are sharply pointed and not depressed or lobe-shaped as in the other ridges. Starting from the middle of each ridge, except the first one, the papillæ decrease in size laterally and finally disappear at the extremities. From the third to the seventh ridge inclusive there is a large papilla occupying the middle point of each ridge, of which the largest one is on the seventh, measuring slightly over 2 mm. wide and 2 mm. long. These larger papillæ probably represent the fusing together of two or more smaller papillæ in this region. The eighth ridge has a notch in the middle line, caudal to which is a conspicuous papilla probably corresponding to those in the middle of the preceding ridges in spite of its caudal location. At the middle of the ninth ridge there are two slightly larger papillæ which are slender,

slightly curved, and pointed, instead of being rounded as the others. The last ridge is broken up at the middle, and no large papilla is found in this region, but about 4 mm. caudal to this point is situated the posterior large papilla, on the surface of which minute tubercles are recognizable with the aid of a hand-lens.

Besides the general shape of the anterior large papilla and the arrangement of the papillæ between the ridges, two important surface characters are seen. One is the notch on the right portion of the seventh ridge as shown in text-fig. 1, which character is absent on the left side, once more differentiating the specimen in question from the hard palate of the cat, on which a small notch is found on each side. Another is the cephalad shifted angle of the right half of the last ridge. This ridge appears to be formed by the fusion of two segments. The left half of this ridge curves gradually without discontinuation throughout its entire length. There is no angle in this section of the ridge.

The space between each two ridges in the anterior region of the palate is comparatively narrow and mainly occupied by papillæ, but posteriorly the two rows of papillæ become further apart from each other. The mucosa covering each space is smooth or slightly wrinkled.

Owing to the delayed fixation the tunica propria and the tela mucosa are not well preserved, but the stratified squamous epithelium still permits histological examination. The cornified layer is very thick. At the apex of the larger papilla on the edge of a ridge the cornified layer becomes chitinized, forming a brownish capsule (text-fig. 3), while covering the smaller papilla and the smooth surface it is not chitinized. Under the chitinous capsule the cells are greatly modified, their wall is either absent or not recognizable owing to the poor fixation. Their nuclei are quite distinct. The cells are concentrically arranged, sometimes in one, sometimes in two or more whorls. In serial sections each concentric arrangement of cells covers the apex of a papilla of the tunica propria coming in from deeper region. At the base of the larger papilla under the brownish capsule, in the outermost portion of the stratified squamous epithelium immediately beneath the cornified layer, the cell-walls are distinct and the cell-bodies are mostly flattened. In the middle region of the stratified squamous epithelium the cells are rounded or more or less polygonal, and in the innermost region they are more or less compressed. In both of these regions, especially in the middle one, the cell-bridges are very distinct. The basement membrane is very clear, definite, and comparatively thick.

8. External Sexual Differences in the Terebellid Worms.

By W. B. Benham, D.Sc., F.R.S., F.Z.S.

(By permission of the Trustees of the British Museum.)

[Received November 16, 1926: Read February 22, 1927.]

(Text-figures 1–5.)

It was Meyer who, in 1887, first described in detail the arrangement of the nephridial and genital tubes in the family Terebellidæ, and as every student of the Annelids knows, he showed that there is internally a diaphragm separating the cavity of the branchiferous from that of the following segments, and it is in the latter that the genital cells are produced. Some of the tubes lie in front of this diaphragm, the rest behind it. Each of these tubes has a funnel opening into the cœlom, and those that open before the diaphragm belong to excretory tubes or nephridia, those that open behind it belong to the genital ducts. The pore of each is carried by a more or less evident papilla and, as in other Annelids, this is situated on the segment next following that in which the funnel opens.

The number of nephridia varies from one to three in different genera (and apparently only in the single species of the genus *Lanicides* is a nephridium absent, according to Hessle); that of the genital ducts has a greater range in number.

In *Amphitrite rubra*, which Meyer studied more particularly and illustrated with beautiful figures, there are three pairs of nephridial tubes opening externally on the segments ii., iii., and iv., *i.e.*, on the second branchiferous, the first notopodial, and first neuropodial segments respectively. Then follow in this species some "9–11" papillæ belonging to the genital tubes. All these papillæ are situated above the neuropodia or "uncinigerous tori," and the anterior nephridial papillæ may even be above the level of the notopods.

The number of the tubes of each kind varies in different genera and Hessle (1917) has made use of the facts in characterising them; he gives diagrams illustrating the form and number of the tubes as seen by dissection, but has but little to say of the nature of the papillæ.

So far as I have been able to ascertain, no zoologist has noted that the character of the genital papillæ presents marked differences in the two sexes during the breeding season.

I have searched for information on the matter in the recent volume by McIntosh, issued by the Ray Society (1922), wherein he gives a useful résumé of all previous important observations on the anatomy of the species or genus under consideration. I have looked through his various contributions to the 'Annals

and Magazine of Natural History,' but without finding any statement to the effect that there is any such sexual difference in the nature of these papillæ. Meyer does not refer to it, nor does Hessle allude to the matter.

In short, in looking through the literature I have found only one reference to any such difference and that is rather vague. It occurs in an article by de Saint Joseph in his account of *Nicolea venustula*, where he writes (1894, p. 210) as follows:—

"Il y a 3 paires d'organes segmentaires; la 1ère très petite en avant du diaphragme œsophagien dans le 3me segment, les 2 autres trois fois plus grosses en arrière de ce diaphragme dans les 6me et 7me segments. Chez les males, comme l'a observé et figuré Malmgren pour la *Nicolea arctica* .... il y a un petit cirre au-dessus des soies aux 3me et 4me segments sétigères, mais peut-être n'est-ce que la papille où débouchent les organes segmentaires et qui est plus dévelopée chez les mâles que chez les femelles."

Comparison of Malmgren's two figures, the one (fig. 66) of the male, the other (fig. 67) of the female, suggests, in the light of my observations on the females of various species described in this article, that the epidermis in the latter figure is glandular; his drawing represents the long and delicate filamentous papillæ in the male, but in the female the artist seems to have intended to indicate a difference in the texture of the skin in the corresponding position and on the neighbouring segments (1865, pl. xxiv.); so that, as I show below, the papillæ are overgrown by the glandular tissue and so concealed.

McIntosh, von Marenzeller, and others have described the arrangement of these papillæ for various genera and species, and it seems pretty evident that in some instances the account of a species indicates that the author had a male under observation, in others a female, for it is stated for some that papillæ are present (*i. e.*, a male) and in others that no papillæ are evident (*i. e.*, female).

In working over the large amount of material gathered, during the two expeditions into the Antarctic Seas, by the 'Aurora' and the 'Terra Nova,' I have had the opportunity of studying both males and females of the same species. When recording the results of my investigations in the Report of the Mawson Expedition (1921), I had not paid attention to this matter; it was only while at work on the annelids collected by the 'Terra Nova' Expedition that I was struck by the fact that there is a constant and definite difference between the sexes of the species of Terebellids examined.

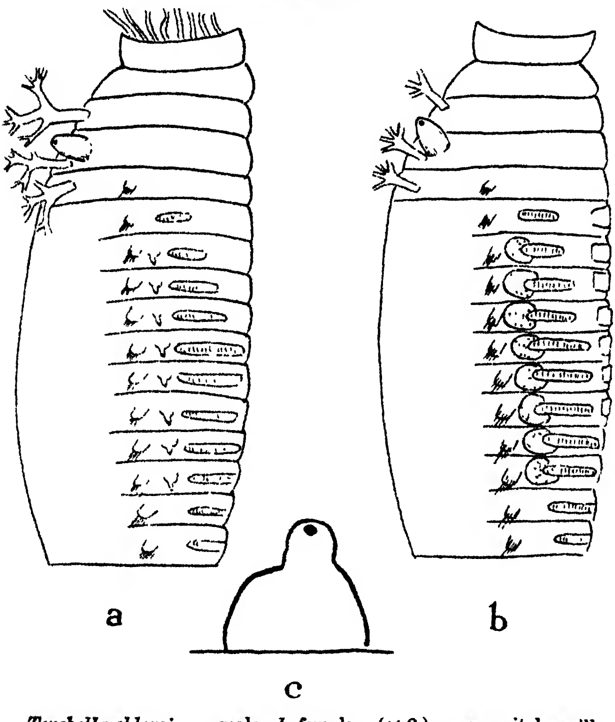
In the male the genital papillæ are comparatively small slender tubes or cones, whereas in the females either the papillæ themselves have glandular walls or the area of the skin in their neighbourhood is thus modified, so that there results a conspicuous cushion of considerable extent, and this glandular development of the epidermis obliterates the form of

the outstanding processes, so that no "papillæ," in the ordinary sense of the word, are visible.

The number and position of the genital papillæ in the two sexes are identical for a given species; but the form and relative size are very varied in the different species examined.

It must, however, be borne in mind that as sexual maturity is periodic (see Meyer), it is probable that in the intervals this sexual difference in the nature of the papillæ disappears. I give details of a few genera, illustrated by figures * which will show the range of these differences.

Text-figure 1.



Terebella ehlersi. *a*, male; *b*, female. (× 2.) *c*, a genital papilla of the male, much enlarged.

1. Terebella ehlersi Gravier. (Text-fig. 1.)

In the male, as in the female, there is one very prominent nephridial papilla of relatively enormous size, on the second branchial segment, high up the side of the body, in line with the gills: this is followed in the male (in which sperm morulæ were

* The drawings are somewhat diagrammatic, being intended to show only the disposition and form of the papillæ.

present in the cœlomic fluid) by a series of eight "genital" papillæ, situated immediately above the neuropodial tori of the segments 6–13; *i. e.*, above the 2nd to the 9th tori.

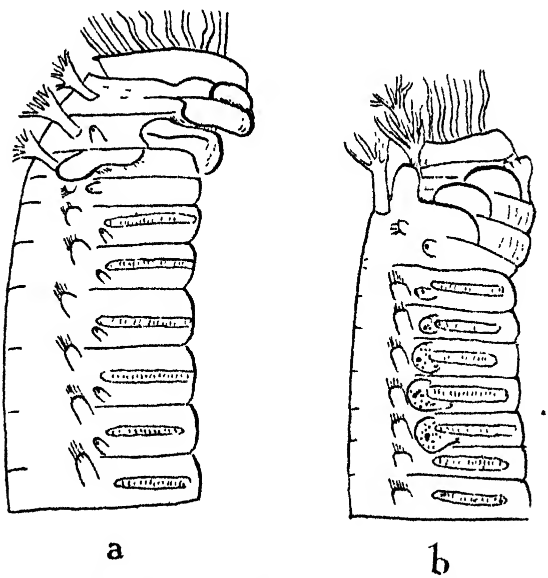
These genital papillæ have a characteristic form which I have not met with in any other genus that I have studied; each is mammilliform, springing from the body-wall as a low rounded swelling from which it is continued as a short narrow tube, carrying the pore at its apex.

In the female the eight genital papillæ appear as glandular areas, each of which occupies the entire length of the segment, extends from the neuropod up to the notopod, and passes down the side of the former, both in front of it and behind it, to a greater or less degree.

2. Amphitrite kerguelensis McIntosh. (Text-fig. 2.)

There are three nephridial papillæ on each side of the body: the first is below the 2nd gill, the second below the 1st notopod,

Text-figure 2.



Amphitrite kerguelensis. *a*, male; *b*, female. (× 1½.) The female individual was extracted from its tube by tearing the wall away; the "flaps" are thus forwardly compressed so that the first gill and the anterior nephridial papilla are concealed.

and the third on the 1st notopodial segment, as Meyer described for *A. rubra*. They are small, and owing to the great size

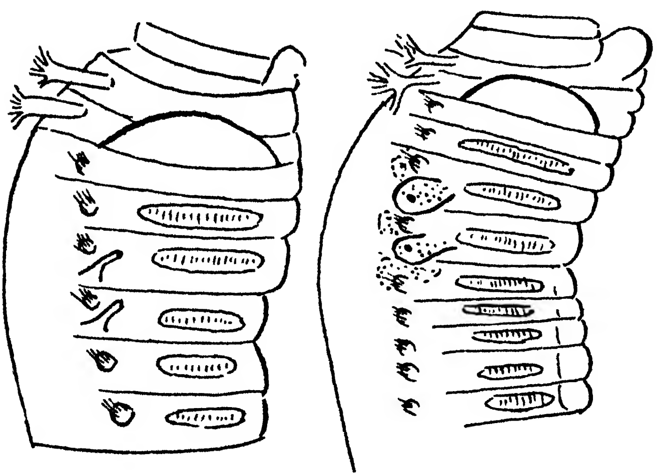
of the "flaps" in this species, especially of the fourth, the anterior papilla is apt to be hidden if this flap has been pressed forward during preservation.

Then follow four genital papillæ on the succeeding segments. In the male these are short, narrow, and conical, arising near the hinder margin of the segment at the level of the upper end of the neuropodial torus, and similar in all respects to the nephridial papillæ.

In the female these four papillæ have the form of conspicuous glandular cushions occupying the length of each segment, reaching up to the notopod, and creeping down behind the neuropod for some little distance. The pore is near the upper end of this cushion.

Hessle, in his diagram of the condition of the "nephridia" in his genus *Neoamphitrite* shows, and in his diagnosis states, that it is characterised by having three prediaphragmatic nephridia, whereas the genus *Amphitrite* has but one, which lies in the 3rd segment. Consequently, *A. kerguelensis* should be placed in his new genus, though he retains it in the old one, for he found but one nephridium in the species.

Text-figure 3.



a b

Lanicides vayssierei. *a*, male; *b*, female. (× 2.)

3. Lanicides vayssierei Gravier. (Text-fig. 3.)

I see no pre-diaphragmatic papilla, nor was Hessle able to find any nephridium (1917, p. 62), so that apparently this species, the only one in the genus, is without a true excretory tube. There

are only two genital papillæ, which are situated on the 5th and 6th segments, lying behind the 3rd and 4th notopods.

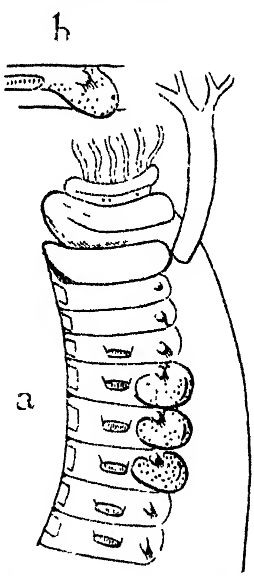
In the male these are long, narrow, and tubular, slightly expanded at the base, where they spring from the body-wall at the level of and just behind the chætigerous lobes.

In the female these two papillæ are much enlarged, rounded above, and limited to the region behind the notopod, projecting beyond the hinder margin of the segment; each spreads downwards as far as the upper end of the neuropod. The aperture is quite distinct at the upper end of the papilla. In addition, the epidermis above the 3rd, 4th, and 5th feet is glandular.

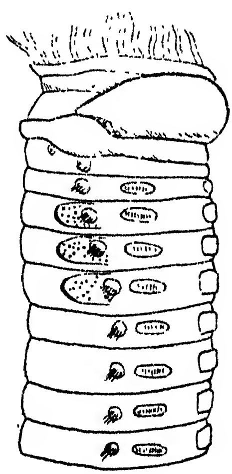
4. Pista godfroyi Gravier. (Text-fig. 4.)

Of this species I have studied four female specimens, all filled with eggs which show through the translucent body-wall; the sex was, moreover, confirmed by examination of the cœlomic fluid. There is but one nephridial papilla, situated on the

Text-figure 4.



Text-figure 5.



4. *Pista godfroyi*. *a*, female. (× 4.) *b*, genital papilla, enlarged.
5. *Leæna wandelensis*. Female. (× 5.)

post-branchial segment; it is small and in line with the notopods, for one of which it might be mistaken.

The three genital papillæ lie at the same level on the 3rd, 4th, and 5th chætigerous segments. Each is a very large rounded

glandular mass projecting behind the notopod as far as the intersegmental furrow and extending upwards above the foot and then downwards behind it, nearly reaching the neuropod. In its upper region is the pore, which in the less sexually mature worm is circular, but in the more mature is converted into a longitudinal slit by the upgrowth of the glandular tissue.

I have not been able to study the male of this species, but I have given a figure of the male of *P. mirabilis* McInt. in my Report of the 'Aurora' polychætes (1921, pl. ix. fig. 97), in which it will be seen that the genital papillæ are situated in the same segments as in the present species; they are small, short, and tubular.

Gravier mentions only the postbranchial papilla in his account of this species, and his figure probably represents a male, for he could scarcely have overlooked the large conspicuous glands of the female, if it had been in the breeding season.

Ehlers (1908, pl. xx. fig. 11) shows also only this papilla for *P. spinifera* (which I have shown to be synonymous with *P. mirabilis*); he does not mention any other.

5. Leæna wandelensis Gravier. (Text-fig. 5.)

In my report on the 'Terra Nova' worms I have shown, as I believe, that this species is identical with Ehlers's *L. arenilega*.

The genital papillæ are enormously developed in the female as huge glandular lobes on the 2nd, 3rd, and 4th neuropodial segments; they surround the notopods above and extend, as usual, along the whole length of the segment. Each is opaque in its middle and somewhat translucent at the sides: it sends a short prolongation down the front and a much greater one behind the notopod, reaching nearly to its lower border. It terminates above in a distinct rounded protuberance, high up on the side of the body at about the level of the nephridial papilla; but I was unable to detect the pore, which is no doubt occluded by the glandular development.

The nephridial papilla is very small and is not always recognisable in this small worm as it lies immediately behind the second "flap."

In a male in which I found sperm morulæ, the genital papillæ are equally small, so that unless one were searching especially for them one would overlook them: indeed a high magnification under a dissecting lens is required for their recognition.

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9. A remarkable Scelionid (Hymenoptera-Proctotrypoidea) from South Africa. By James Waterston, B.D., D.Sc., F.Z.S.

(Offered for publication by permission of the Trustees of the British Museum.)

[Received November 16, 1926: Read February 22, 1927.]

(Text-figures 1 & 2.)

In the extensive collection of parasitic hymenoptera—upwards of 20,000 specimens mostly of small size—recently made by Mr. R. E. Turner in S. Africa, is a single example of a Scelionid of striking appearance and unusual structure. I was at first inclined to treat this as representing a new genus, but on reconsideration have assigned it, for the present, to

Encyrtoscelio Dodd.

Proc. Roy. Soc. Queensland, vol. xxvi. p. 119 (1914).

In the South African insect the following characters appear to be of generic value:—

Stoutly built species. Head, thorax, and abdomen closely fitting, and of approximately equal breadth. General appearance from above Tortoise-like; body elliptical, the sides a little concave medianly. Dorsally distinctly convex and evenly curved both transversely and lengthwise; ventrally flattened.

Head:—*Dorsal* aspect parabolic. Eyes widely separated, ocellar triangle large, a stout flange anteriorly between vertex and face. *Antero-ventral* aspect similar in outline to dorsal. Raised area above mouth-edge. Small subcircular plate between the toruli, which are set low down on face. In *profile* subtriangular. Mandibular "beak" at postero-ventral angle. Genal keel fine, but distinct. From *posterior* aspect subcircular. A fine occipital keel runs parallel with, and just below, the descent from the vertex, and reaches ventrally on each side to the insertion of the mandible.

Antennæ:—12-jointed with five in club. Mandibles long, dependent, apically peculiarly bidentate; maxillary palpus with two joints, labial with one.

Thorax:—Pronotum only linearly visible from above, developed mainly in two triangular pleural sclerites. Propleuræ meeting ventrally. Mesoscutum transverse, without furrows. Mesepimeron narrow, indistinctly indicated, crenulate. Mesosternum and mesopleuræ separated by a keel. Scutellum broad, overarching both metanotum and propodeon. Both the latter short and mainly perpendicular. Propodeon rugose with short postero-lateral angle.

Wings:—Fore wings with only traces of neuration—the subcostal, marginal (partim) median and anal veins being suggested. Spoon-shaped with short "handle"—the larger, concave, distal disc closely enfolding the abdomen. Apical fringe of very long curved, and, for the most part, strongly flattened cilia.

Hind wings normal, no nervures, three hooklets, fringe long.

Legs normal, tibiæ and tarsi spinose; tarsal ungues simple, slender, not greatly curved, awl-shaped, the more swollen base bearing 1–2 short spines.

Abdomen broad, 4–5 tergites visible from above, the second being much the longest; 6 sternal plates visible from below.

It should be noted that Mr. Dodd describes *Encyrtoscelio* as having *no* ocelli, while the mandibles are tridentate. The note as regards ocelli is probably an error of observation, as it is very unlikely that a fully alate form in this family should be destitute of these organs. As regards the mandibles, my first impression was that they were tridentate—an illusion caused by their close interlocking apically, and dispelled by dissection.

ENCYRTOSCELIO TURNERI, sp. n.

♀. *Colour-notes.*

Body uniformly piceous black, shining on dorsal aspect of head and thorax anteriorly, but duller elsewhere. (When the wings are in position, wrapped about the abdomen, the latter may show from some points of view a silvery interference effect.)

Fore wings basally hyaline, the obsolescent nervures (faintly) and the apical one-third with the long recurved cilia (more definitely) infumated.

Hind wings nearly hyaline, a little infumated at radix, and along the edge. Coxæ and antennal club concolorous with body: all femora, tibiæ, and maxillæ clear piceous, not so dark as body. Tarsi, antennæ to middle of funicle, and palpi still paler. Mandibles like tibiæ with apical teeth darker.

Structure.

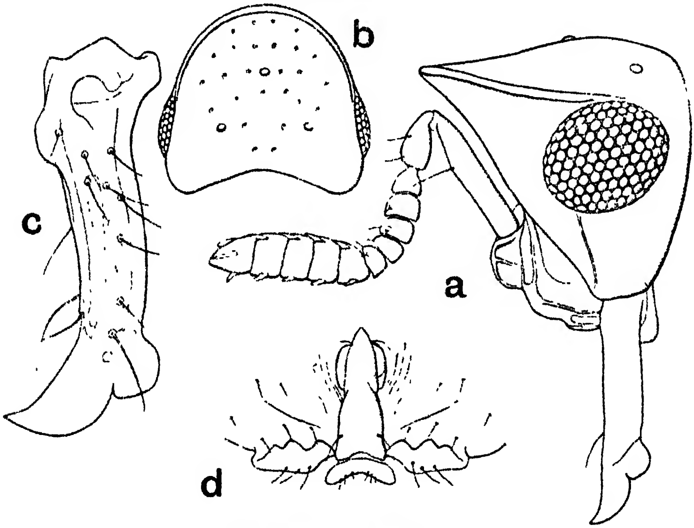
Head:—Length about ·3 mm. dorsally (text-fig. 1 *b*), nearly smooth with many distinct somewhat widely apart setigerous punctures.

Ocelli small, forming a nearly equilateral triangle. In profile (text-fig. 1 *a*) the anterior flange ends above the bare eyes. Below the level of the flange the surface shows a delicately impressed network of large cells. From in front (text-fig. 1 *d*) the inter-torular prominence, subcircular in profile, is broad and medianly grooved. Antennæ (text-fig. 1 *a*): length ·46 mm. Scape (11 : 2) as long as pedicel and first six joints of funicle (*i.e.* up to the end of the first club-joint) or one-fifth longer than the club. Pedicel (2 : 1) about one-third the scape. In the

funicle the first joint is campanulate, and as broad as long. The last joint of the club longer than broad. The other joints transverse; 4–7 inclusive being only half as long as broad. Relative proportions as follows:—i. 10 : 10, ii. 9 : 11, iii. 8 : 11, iv.–v. 5 : 10, vi. 8 : 16, vii. 9 : 18, viii. 10 : 18, ix. 10 : 17, x. 18 : 14.

Chætotaxy etc.:—On the scape one of the ventral bristles (at one-third from the apex) is as long as one-third of the joint itself. Up to the first funicular the joints bear only ordinary bristles; on 2–5 one or two sensoria occur, while the club-joints have three to four each.

Text-figure 1.



Encyrtoscelio turneri, sp. n.

a. Head in profile. *b*. The same from above. *c*. Left mandible.
d. Sub-torular area, clypeus and labrum.

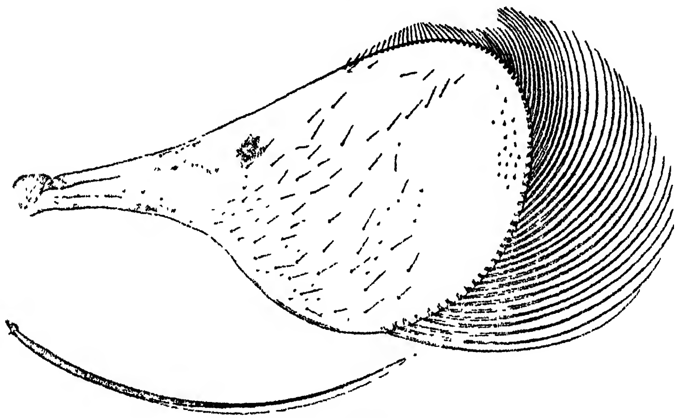
Trophi:—Labrum (text-fig. 1 *d*) narrow (1 : 4), closely fixed below the clypeus, distinctly concave and with about ten minute fringing bristles. Mandibles: the left jack-boot shaped (text-fig. 1 *c*), ·2 mm. in length. Stipes and mentum bare, the latter with two clear pustules; joints of maxillary palpus equal, first joint expanded (5 : 3) with about six bristles on inner face, second joint (5 : 2) with five bristles, of which two are terminal; galea, three bristles at apex, and one (stouter) at side near base; labial palpus (2 : 1) pear-shaped with three bristles.

Thorax:—Mesoscutum (1 : 2): length ·18 mm., breadth ·36 mm., about as smooth as the head, but with the same network of large unraised cells. Scutellum: length ·13 mm.,

breadth ·29 mm., covering completely the metanotum, and the propodeon, save for its postero-lateral angles, broadly truncate, and slightly concave posteriorly. Propodeon narrowly in middle practically smooth, with six to seven short ridges on each side forming two irregular rows of cells. Spiracles moderately large at antero-lateral angle dorsally. All the pleural surface dull, with a raised pattern, rather finer than on dorsal aspect. The metapleuræ, in particular, are roughened.

Wings:—Fore wings (text-fig. 2) (2 : 1), length ·57 mm. Hind wings (4 : 1), length ·48 mm., the longest of the cilia as broad as the wing.

Text-figure 2.



Encyrtoscelio turneri, sp. n.
Fore wing, with detail of one of the flattened marginal cilia.

Legs.

Fore legs:—Length ·6 mm.; coxæ posteriorly with a slight ridge, or fold, extending downwards for about one-third from the base; femur (5 : 1) longer (8 : 5) than tibia (10 : 3); tarsus shorter than femur, and about one-third longer than tibia. The latter with a spine on antero-dorsal edge at one-third from apex, two spines ventrally before spur (the latter flattened distally), eight spines round apex (anterior and posterior faces). First tarsal joint curved, two short spines on dorsal edge; comb of twenty-five or more spines. At apices of joints 1–4 are 2 spines dorsally and 1 ventral. Ratio of joints—30 : 7 : 7 : 6 : 15. Mid-legs as long as fore-leg; femur (5 : 1) longer (4 : 3) than tibia (about 5 : 1); tarsus just longer than tibia; two dorsal spines on tibiæ, one at one-half, the other at one-third from apex, where there are, besides the spur, five larger spines anteriorly, and five smaller and more closely set posteriorly. First tarsal joint one median dorsal spine, and six at apex. Ratio of joints—18 : 14 : 11 : 9 : 15.

Hind legs:—Length ·8 mm. Femur (4 : 1) as long as tibia (about 7 : 1); tarsus longer (10 : 9) than either femur or tibia. Tibia: besides the usual dorsal spine at one-third from apex, there is a small one near base; one preapical ventral spine, three at apex anteriorly, and comb of eight posteriorly. The spur is just over half the length of the first tarsal joint, which bears five (single or double) plantar spines, and three in a row on anterior aspect. Ratio of joints—40 : 20 : 14 : 11 : 15.

Abdomen:—Length ·34 mm., breadth ·4 mm., lengths of the first four visible tergites 35 : 50 : 32 : 18, sternites 25 : 50 : 20 : 23. The ovipositor (entirely internal) is five-sixths of the length of the abdomen. First tergite strongly margined above the concealed petiole, from the margin crenulate (8–10 short ridges) to half its length medianly. From above the antero-lateral angles are distinct, and from the margin before each angle there comes back a fine irregular ridge, not quite parallel with the lateral edge, but a little ad-medianly inclined, and reaching to two-thirds of the length of the tergite. The sides of the abdomen are gently convex, and it is posteriorly slightly truncate. The tergites overlap broadly, and the enclosed ventral area is trapezoidal in outline. Both dorsal and ventral aspects are rough, the pattern large and strongly raised. On the tergites are a few minute scattered bristles, chiefly at sides.

Length about 1 mm.

Expanse about 1·5 mm.

Holotype ♀ in British Museum.

South Africa, Cape Province, Mossel Bay, xi. 1922. R. E. Turner.

10. Loss of Memory accompanying Metamorphosis in Amphibians. By Major S. S. Flower, O.B.E., F.L.S., F.Z.S.

[Received October 28, 1926: Read February 8, 1927.]

The profound alteration in the respiratory system of an Amphibian at metamorphosis is, as is well known, accompanied by modifications in external appearance and in many cases by the complete reorganization of the alimentary system. In *Salamandra* the alimentary system does not alter. The object of this paper is to show that there must be some sudden, but so far probably unrecorded, change, at metamorphosis, in the nervous system.

Out of a number of European Spotted Salamanders (*Salamandra salamandra*) born on my writing table at Tring, Hertfordshire, early A.M., 16 May, 1926, I took three for individual attention, and proceeded to tame them as one would a fish.

Each larval Salamander was kept in a separate glass jar, but all under similar conditions, on the table. All three soon became tame enough to show no fear at being approached, and would take food from one's hand. After some weeks they even, when hungry, called attention to themselves by active movements and by sending out bubbles which exploded on reaching the surface of the water.

As the time for metamorphosis approached (shown by the reduction in the size of the external gills, the absorption of the tail-fins, and the gradual assumption of the adult markings and colour) each animal developed a great appetite and freely swam to one's hand to take earthworms.

The dates of metamorphosis of the three individuals were 31 August, 5 September, and 13 September, 1926, when the external gills entirely disappeared.

The animals were kept in the same glass jars in which they had spent all their larval life, they now frequently left the water and climbed on to the above-water structures provided for them, but all memory of their human attendant was, in each case, lost on the day of metamorphosis.

Close approach to the jar frightened them, they tried to evade capture in the hand and struggled wildly if picked up, and they would not feed. The process of taming had to be begun again from the beginning as if they were fresh-caught wild animals. It took from about one to five weeks to get them tame enough to come to the hand.

The food given before and after metamorphosis was exactly the same, small earthworms.

At the time of writing, 26 October, 1926, all three Salamanders are alive and looking well, but differ individually in degree of tameness.

Addendum. 25 February 1927, these three Salamanders alive. Two (dates of metamorphosis 31 August, 5 September) very tame, one (date of metamorphosis 13 September 1926) unreliable.

11. *Bipinnaria asterigera* (Echinoderma), from the Northumberland Plankton. By Alexander Meek, F.Z.S.

[Received November 11, 1926: Read February 22, 1927.]

(Text-figures 1–22.)

In September 1925 we were very pleased to find that the plankton nets of the 'Evadne' were capturing specimens of the large Bipinnaria which has been called *Bipinnaria asterigera*. The larva was distributed from about 30 fathoms off the Longstone to about 22 fathoms off Newbiggin, and was got at all depths, but mainly from mid-water to the bottom. It was obtained, therefore, only at our outer stations, and was not seen in the hauls made at the inner stations. Altogether over 100 examples were obtained. Most of the specimens bore well-developed starfishes, and we were fortunate enough to get a starfish which had recently been freed.

The larva had not been observed before during the many years in which netting has been done. It attracted our attention on the boat from its large size and the large anterior or cephalic lobe and processes. McIntosh, however, records that the larva was obtained in St. Andrew's Bay in the autumn of most years, and from his remarks it is evident that it is the same species which has now appeared in the Northumberland region *. It is therefore plain that its occurrence off the coast of Northumberland is one of the many instances we have had to record of the effects of the abnormal activity of the Atlantic water in recent years.

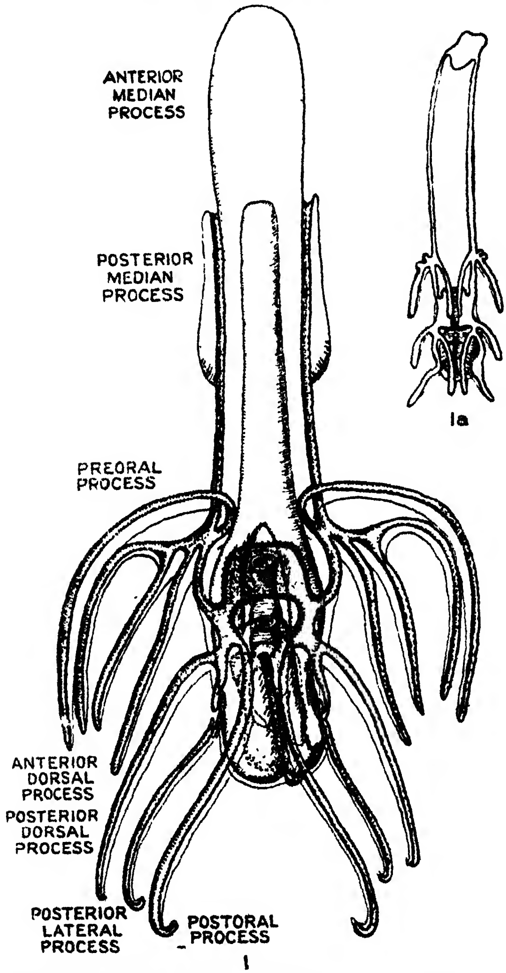
Still larger numbers of Bipinnaria and two newly-freed starfishes were captured in 1926. The larvæ appeared in August at the two most northerly stations—off Berwick,—and in September were generally distributed along the Northumberland coast, but they were most numerous and presented more advanced stages in the southern part of the area. They were again most prevalent in and below mid-water, but occurred in all areas practically from surface to bottom; and on this occasion they had penetrated conspicuously to the inshore stations.

The developed starfish in each case had a rich brown disc, due to the stomach, and yellow rays, and was so like our common cushion star, *Hippasterias*, in general appearance and so unlike *Luidia*, to which this Bipinnaria is ascribed, that doubt was raised as to the correctness of the opinion. Besides, there was the question of the disparity in the number of the processes

* Prof. McIntosh has now informed me that the *Bipinnaria* was found only once in St. Andrew's Bay.

according to successive observers. It was therefore decided to make the attempt to describe the specimens, and, although the material had been preserved simply in formic aldehyde, to call

Text-figures 1 & 1 *a*.



Ventral view of *Bipinnaria asterigera*. 1 *a*—young stage.

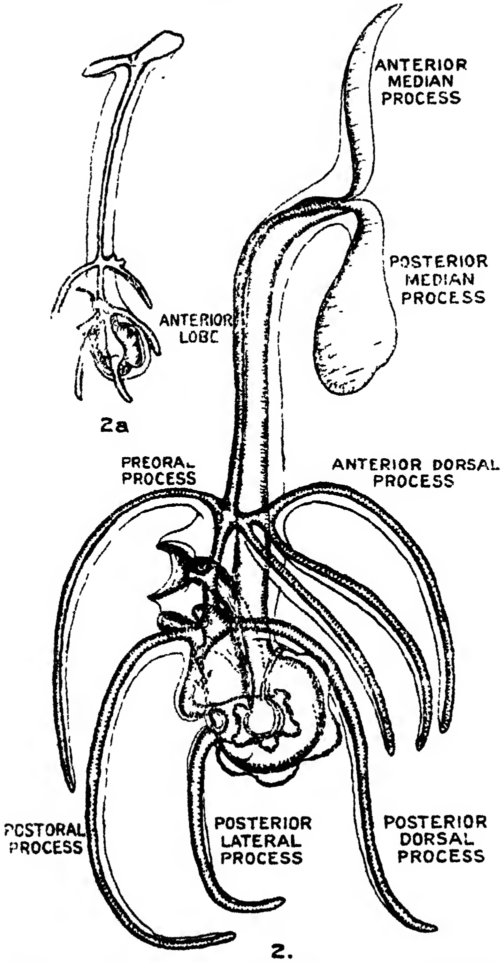
in the aid of mounted specimens and sections to review, if necessary, Bury's description of the cœlomic cavities.

The Larva.

Two forms were procured, a large and a small. The small measures 2·5 to 3½ mm., and the bifurcations of the anterior

lobe are about as long as the lobe itself. The others measure 5 to 10 mm.—likewise in the preserved state,—and the branches of the anterior lobe are shorter than the lobe itself. The larger specimens have a length on the average of about 8 mm., but

Text-figures 2 & 2 *a*.



Lateral view of *Bipinnaria asterigera*. 2 *a*—young stage.

when captured it was observed that the length was about 15 mm. The high and low forms are not due to degree of development, for the small specimens have starfishes at all stages. In general morphology they are otherwise alike. The descriptions which follow refer to the larger form.

It will be seen from the literature that authors are agreed as to the general bipinnarian arrangement of the processes. But they are not in agreement as to the shape of the branches of the anterior or cephalic lobe, nor as to the branches of the anterior dorsal process.

Garstang and Bury figured the posterior process of the anterior lobe as similar to the anterior process, but Koren, Danielssen, and Müller indicate that the posterior process is broader and slightly bifid distally. This is the condition likewise in the Northumberland specimens, as is shown in text-figs. 1 and 1 *a*, and 2 and 2 *a*.

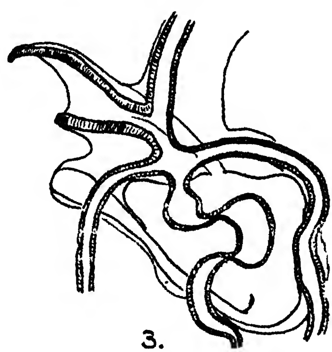
The anterior dorsal process, according to Bury, was simple and unbranched, but as figured by Garstang was bifid. Still another branch was introduced in the figure by Johannes Müller, which, as will be seen, must be attributed to the anterior dorsal process also, although the figure does not make that quite clear. It is more than probable that these varieties do occur and point to specific, if not generic distinctions, also to growth, for text-figs. 1 *a* and 2 *a* indicate that the process is at first single; nevertheless it was not surprising to find that the master-hand of Müller had not been at fault, for the Northumberland examples were found to have six processes of the postoral band, three of which were branches of the anterior dorsal process, as is shown in text-figs. 1 and 2. In the young larva the posterior branch is well developed, and the anterior two appear together as blunt protrusions (text-figs. 1 *a* and 2 *a*) at its base.

Still another feature of interest with relation to the ciliated bands attracted attention, more especially when sections came to be examined. It was that in most cases the area of the adult mouth was bounded by a circlet of band structure. Specimens had been drawn which possessed apparently a very short posterior lateral process. Again, the figures of Garstang and Bury both showed a significant bending inwards of this process towards the body of the larva on each side. The suspicion was therefore aroused that the oral patch of the adult was provided by a diverticulum of the larval oral groove. It was difficult, however, to follow the course of the bands over the body of the larva, until it was discovered that the bands could be made more distinct by staining the specimens with safranin. The stain brought into prominence the glandular cells, and it was seen that these were arranged in a series of small patches along the inner border of the band. A preliminary staining with safranin was found also to indicate with the same precision the position of the glandular areas in sections, and this was a welcome morphological guide in following the intricate windings of the processes. The safranin-stained specimens brought into greater clearness the processes and the bands they bore, and it was found in young stages that the posterior lateral process had the disposition indicated in text-fig. 3. The suspicion thus appeared to be converted into a certainty. It will

be observed from the series of sections in the region of the adult mouth that the posterior wall of the process is prominent, whereas the anterior wall is reduced to a minute ridge. In later stages both apparently disappear as such. The only evidence of this is a series of sections of a later stage in which the oral part of the band is not visible. It is possible that the disappearance of the band is associated with the appearance of the adult oral nerve-ring.

Professor MacBride draws my attention to the statement in Balfour's 'Embryology' that in some Bipinnaria the mouth does not close, but moves to the left side in metamorphosis. In this case the œsophagus is lost, but its opening into the stomach marks the region of the adult mouth (see page 169). So far as external morphology is concerned, it is apparent that

Text-figure 3.



Lateral view of body of *Bipinnaria asterigera* to show disposition of ciliated bands on left side.

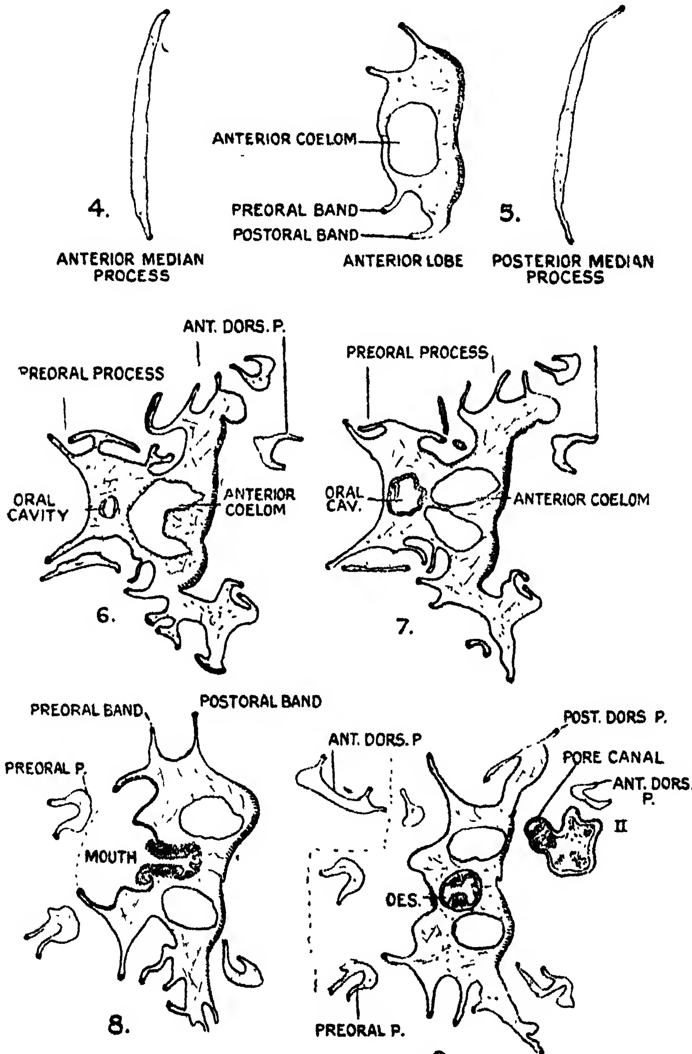
the Northumberland Bipinnariæ are evidently the same species as those examined by Muller, and also the same species as those originally described by Sars and by Koren and Danielssen. The others are either variants and young stages, or more probably other species or genera.

The internal structure, at least so far as the cœlom is concerned, has been described by Bury. His results are confirmed on the whole, but there are points which deserve re-description. As has already been plain, the stages at my disposal are larvæ presenting young and advanced starfishes. The series of sections (text-figs. 4 to 17) refer to one of the earlier stages, and will serve to indicate the more important morphological features.

The anterior lobe is provided on its dorsal wall, which is flattened, with a highly-developed muscular layer of locomotory

importance, the action of which was witnessed by Garstang. The anterior lobe is bent forwards and backwards, and when at

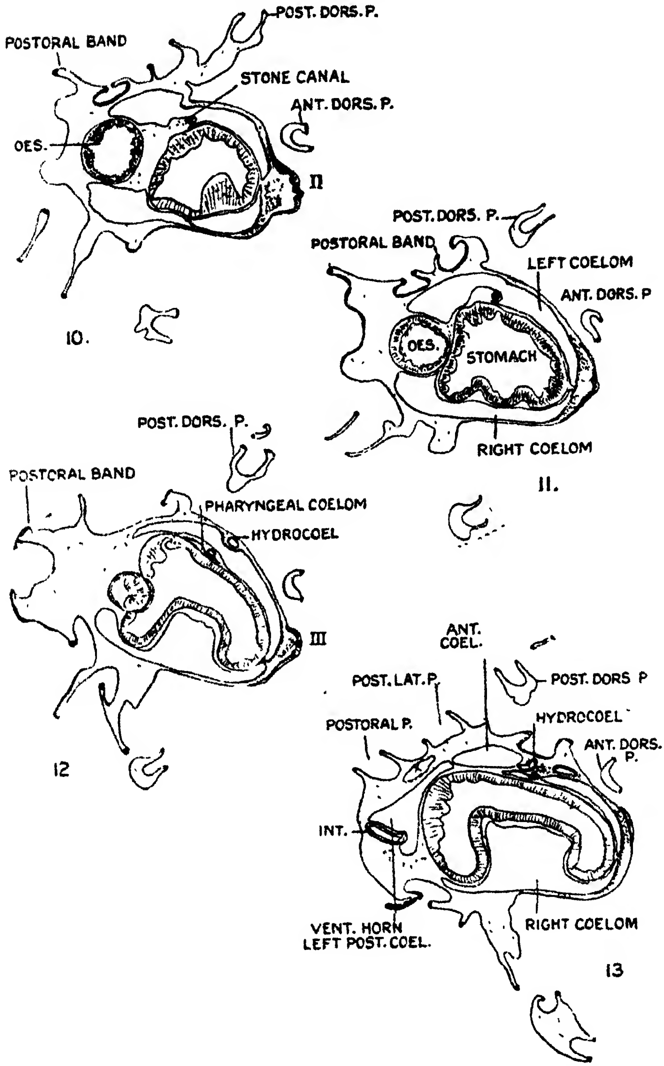
Text-figures 4–9.



A series of transverse sections of *Bipinnaria asterigera.*

rest is directed straight forwards with the two terminal branches nearly at right angles. They form a cup, and probably this cup

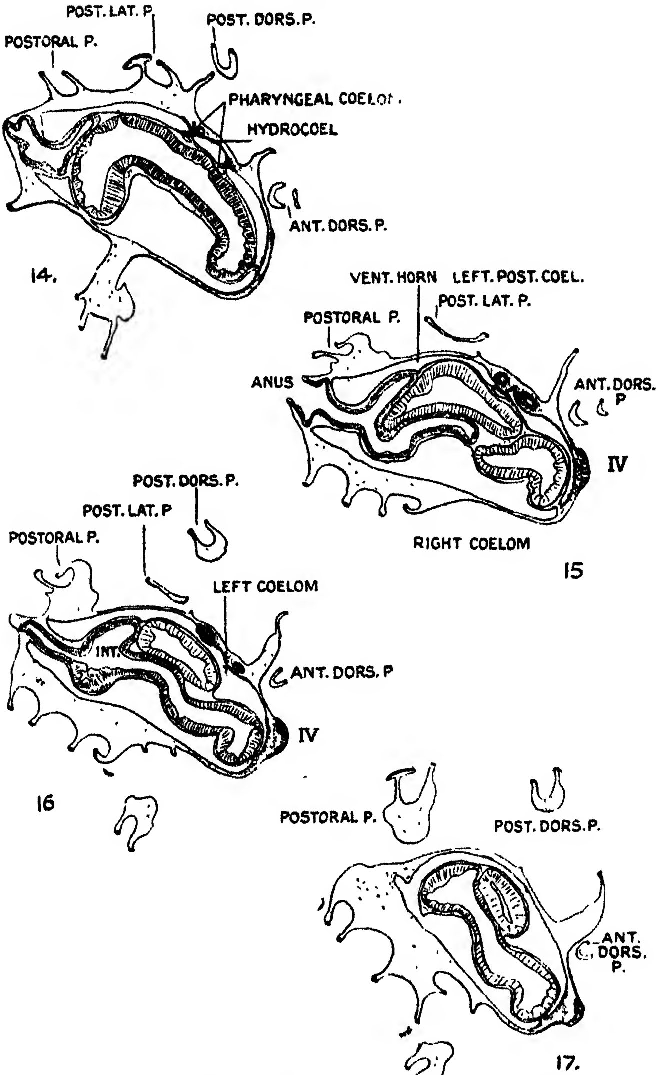
Text-figures 10–13.



A series of transverse sections of *Bipinnaria asterigera*. The space marked "×" in text-fig. 13 is a fold of the external wall.

takes a prominent share in the capture of the food. The killing of the larva has usually the effect of throwing the muscular layer into a state of contraction, with the result that the anterior lobe

Text-figures 14–17.



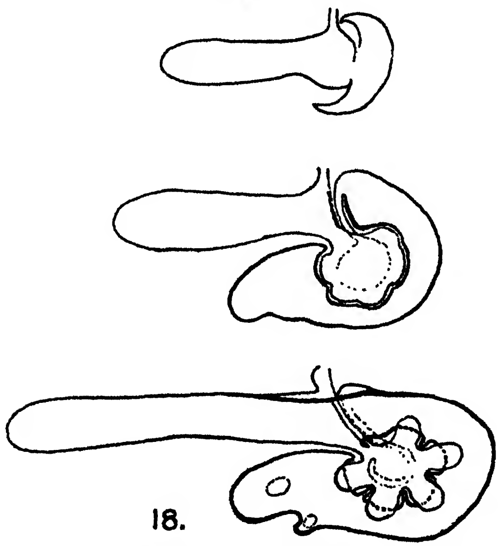
A series of transverse sections of *Bipinnaria asterigera*.

is strongly flexed dorsally. The arched condition of the lobe is indicated in text-fig. 2, but not in its exaggerated state. The layer originates on each side of the dorsal wall of the body of the larva, the two layers merging on the anterior lobe and

dying away at the base of the posterior median process (text-figs. 5–9).

The oral cavity is wide; it is defined above and below by the oral bands and on each side by a ridge. The mouth projects into the cavity as a circular ridge of elongated ciliated cells (text-fig. 8). The long œsophagus opens antero-ventrally into a large stomach, which, in addition to minor foldings, is resolved into a "cardiac" and a "pyloric" chamber. From the second compartment the intestine opens on the right side posteriorly, and after passing along the right ventral side of the stomach gains the mid-ventral region in front of the stomach, and

Text-figure 18.



18.

Diagrams of cœlomic spaces.

expands before bending ventrally to reach the exterior below the postoral band.

At the earliest stage examined, the anterior cœlom, which occupies the anterior lobe, is single. It bifurcates at the base of the lobe into right and left cavities, which are widely separated by the œsophagus and to a less extent by the intestine; but they are put into communication again between the œsophagus and the intestine (text-figs. 13 to 15) and posteriorly to the intestine (text-fig. 17). Dorsally in the body of the larva the two cavities approximate over the stomach, and a mesentery is formed between them which extends all round the stomach and to the expanded anterior end of the intestine.

The right cœlom retains this condition, but it is of interest to

note (text-fig. 10) that it indicates by a slight dorsal indentation a disposition to divide into "medium" and "posterior" moieties.

The left cœlom is greatly modified. It is open to the exterior by a hydropore through the intermediation of a dilated pore canal. Below, the left cœlom is expanded into a hydrocœl, which thus comes to lie, like an island, on the left side and is surrounded by the posterior part of the left cœlom, which is resolved into dorsal and ventral horns. The hydrocœl is five-lobed, the lobes being given off in radial fashion from its outer border and invading the body-wall. In the meantime the stone canal has been established. Authors are in agreement that it originates in asteroid larvæ as a groove on the posterior wall of the tube, which puts the anterior cœlom into communication with the hydrocœl. In the Bipinnaria now under consideration it is already a tube except dorsally below the pore canal, and below it opens into the hydrocœl. In the lower part of its course the lumen is practically non-existent; but as the lumen appears, so does the communication with the anterior part of the left cœlom narrow, and it finally closes. After this, of course, the hydrocœl only communicates with the pore canal and the anterior cœlom by the stone canal.

This is rather complicated, and I have attempted to make it plainer by a series of three diagrams (text-fig. 18). The first is based on Bury's diagram of the early stages in the apportionment of the left cœlom; the second is an intermediate stage; and the third is that now before us. Bury stated that the posterior part of the left cœlom is entirely separated from the anterior part of the cœlom by the horns shown, and I have accepted his statement in constructing the second figure. But in the third figure of the diagram I have shown that the anterior cœlom is in direct and wide communication with the posterior cœlom, as is plain from text-figs. 10 to 13.

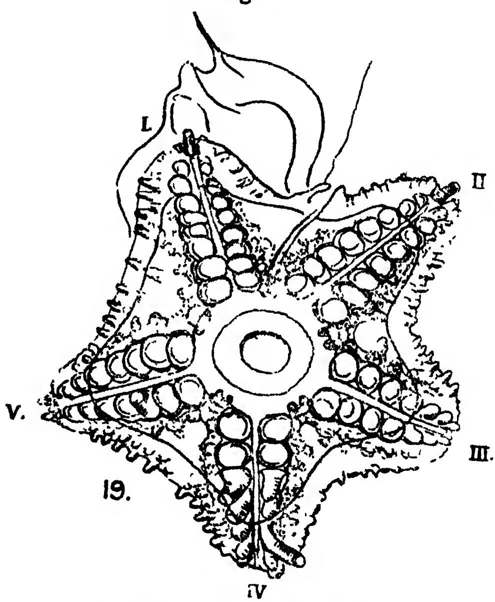
In the diagrams the attempt has also been made to indicate the origin of the pharyngeal cœlom from the dorsal horn of the posterior part of the left cœlom. In the stage before us it is present as a crescentic cavity, the limbs of which are connected by a sheet of cells. The posterior arm of the limb is carried upwards medially to the stone canal and opens into the left cœlom behind the stone canal, as shown in text-figs. 10 and 11. In the diagram, likewise, the blind perihæmal tubes of the posterior cœlom which invade the body-wall between the lobes of the hydrocœl are indicated. One of these is shown in text-fig. 15, and it will be seen that already these tubes are demonstrating an importance by the epithelium becoming columnar.

The dorsal sac lies at the side of the pore canal in the interval between the left anterior cœlom and the right posterior cœlom and above the left posterior cœlom.

The Starfish.

At the time that the hydrocœl is developing in the manner indicated, the body-wall of the larva is becoming modified by the development of the arms of the starfish. The rudiments appear as ectodermal thickenings and protrusions filled with mesenchyme, and the intervals between the arms are also thickened. They appear, as Bury stated, in a series which lie around the body of the larva just on the left side of the vertical mesentery between the right and left cœlomic cavities. Each arm lies over the corresponding lobe of the hydrocœl, and thus no torsion is

Text-figure 19.



Oral aspect of Starfish at late stage.

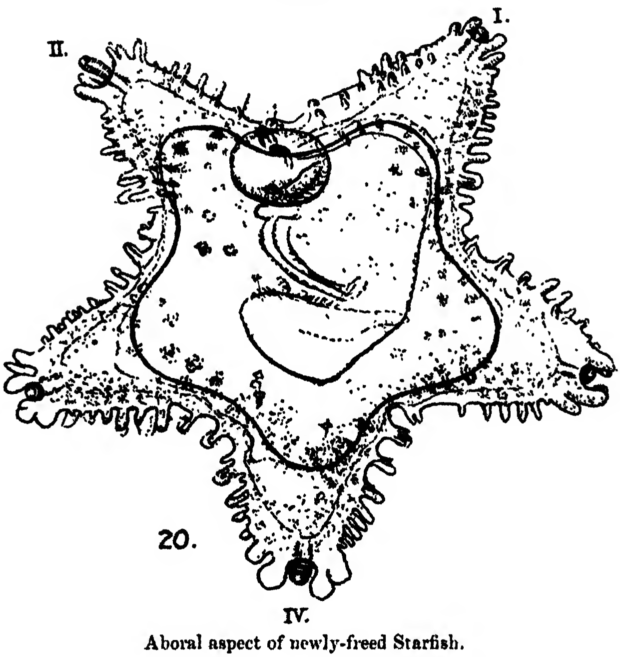
necessary to bring them into relationship. The hydrocœl expands its five lobes, and these at once, each of them, begins to be produced laterally in the body-wall as the rudiments of paired podia. The radial canals are produced and reach the respective arms, and in succession paired tube-feet are formed between the hydrocœl and the tip. There finally arises on the left side of the larva a pentagonal starfish, each arm of which is furnished with ten pairs of tube-feet, and the radial canal terminates in a single foot, which is lodged in a canal and protected by lateral spines. The margin between the arms is richly supplied with roughened spines. In the interradii between the proximal tube-feet skeletal plates are developed, and each is produced into a

spine directed outwards, and a ventral spine and the two groups in each interradius culminate orally in an oral plate, each of which is produced into two spines directed towards the mouth (text-fig. 19).

There is no doubt from the observations of Koren and Danielssen and of the Delaps that, when the starfish reaches this stage, it manages to throw off the whole of the larva not incorporated in it. It divides, in fact, into two living creatures, for the larva thus freed from the starfish to which it has given birth continues to live for some time.

An advanced starfish and a newly-freed starfish are figured in

Text-figure 20.

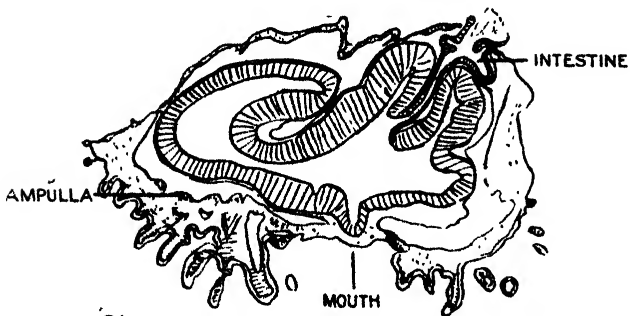


Aboral aspect of newly-freed Starfish.

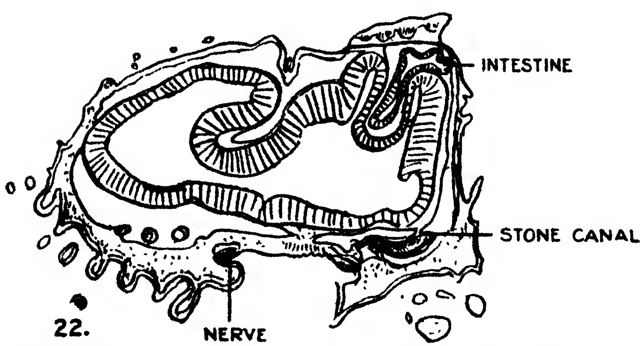
text-figs. 19 and 20. The disc is brilliantly coloured in dark brown and the arms are yellow in colour. The completed starfish measures 3·2 mm. across opposite arms, and the proportion of the disc to the arm is about 8 to 5. The free starfish bears a prominent tumour over the stone canal, and is richly clad with spines around the margin, and areas of calcification may be observed both orally and aborally. The tube-feet are highly muscular, the circular fibres being in the form of prominent rings, and each terminates in a rounded thick cap. This is true also of the terminal foot. There were no signs of pedicellariæ.

The two separated starfishes, obtained in 1926, gave an opportunity for preparing and examining sections. The prominence noted in the previous year's specimen (which had been mounted, text-fig. 20) over the stone canal, and which was assumed to be the madreporite, was found to be much more interesting. It marks the place of closure between the starfish and the larva. It takes place, as would be expected, between the radii, which from the beginning embrace on the left side the region of

Text-figures 21 & 22.



21.



22.

Median sections through stone canal interradius and diametrically opposite arm of a newly-freed Starfish.

the larva anterior to the starfish. This is the interradius of the stone canal and of the original opening from the left anterior cœlom into the hydrocœl. The tumour which marks the event of separation is situated immediately dorsal to the hydropore of the starfish, and is therefore on the aboral side of the interradius.

The two sections drawn (text-figs. 21 and 22) of the separated starfish clearly indicate that the larval œsophagus is completely discarded and the intestine retained. These conditions were

suspected from the fact that in the late larvæ examined last year the intestine was patent and extended far back in the region occupied by the expanding starfish, while the œsophagus was nearly altogether anterior to and outside the starfish, and indicated a distinct constriction at its fusion with the stomach. The process of separation is associated with a rotation forwards of the pyloric chamber of the stomach, and into this chamber the intestine is telescoped. It is evident also that, in sympathy with this rotation on the right side, the cardiac chamber of the stomach is rotated to the left side and expands into the region vacated by the pyloric chamber. This should have the effect of bringing the original œsophagus region of the stomach to the position from which the adult mouth will be pierced. It will be seen from the section through the adult mouth that the structure is not yet completed, and is only indicated by a downgrowth from the stomach—a downgrowth which is apparently the inner end of the larval œsophagus. If this be the case, then, the œsophageal region of the stomach traverses the interradius mentioned to reach its adult position, and, at any rate, the intestine is withdrawn into the starfish almost exactly in the middle of that interradius. It is the anterior interradius, and if we adopt the numbering of the arms suggested by MacBride and Gemmill, arms 1 and 2 are anterior, and 3, 4, and 5 are posterior. The whole of the anterior cœlom is likewise discarded, and the axial sinus appears to be formed entirely from that part of the left cœlom immediately in front of the pore canal.

The characters are unfortunately not sufficient to indicate the starfish concerned, and in the meantime I am inclined to regard it as being a Hippasterias, to which it bears a strong resemblance in shape. It was our first impression.

The conclusion receives some support from the fact that the tube-feet are muscular and each is provided with an ampulla, and that in the living condition they adhere to the walls of the vessel, anchoring the starfish even before it has been separated from the larva.

In September a few Bipinnariæ were captured off Newbiggin, and Mr. Storrow made the attempt to keep them alive at Cullercoats. He was successful for about three weeks, but the larvæ began to disintegrate and the starfishes died. When he and I examined them during this period, we found that the tube-feet were already in constant movement and capable of fixing the starfish. I have to thank the laboratory steward, Mr. Geddes, for the sections and preparations.

Summary.

The characters of the *Bipinnaria asterigera* of Northumberland waters are:—Colour transparent. Shape: long anterior lobe dividing into anterior and posterior median processes (the former

pointed, the latter expanded distally and slightly bifid); the processes are long, and the anterior dorsal process consists of three branches. Size (two forms, a low and a high): preserved they measure ca. 2·8 mm. and 8 mm. respectively; the high form measures alive ca. 15 mm.

The characters of the young starfish to which it gives rise are:—Colour: disc or stomach brown, arms yellow. Shape pentagonal, disc to ray as 8 to 5; hydropore marginal. Spines, mostly simple, columnar, marginal, in several but mainly in 2 to 3 rows; adambulacral skeleton consists of an oral plate bearing two spines projecting towards the mouth and of rudimentary plates external to the tube-feet, each bearing a ventral and an external spine. Tube-feet: one row on each side of arm, muscular and terminating in a rounded conical cap, adherent; terminal tube-foot similar, and enclosed in a canal at tip of arm and protected by lateral spines. Internally each tube-foot is provided with an ampulla.

The original anterior interradius is that of the stone canal and hydropore. It also is the interradius of separation, which means the shedding of the larval structure anterior to the starfish, including the œsophagus. It appears that the œsophageal region of the stomach is rotated to the position of the new mouth, and the intestine is withdrawn at the place of closure into the starfish.

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12. Report on the Deaths occurring in the Society's Gardens during the Year 1926. By H. HAROLD SCOTT, M.D., F.R.C.P. Lond., D.P.H., D.T.M. & H.Camb., F.R.S.Edinb., F.Z.S., Pathologist to the Society.

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In my report for 1925, I stated that there had been a reduction of 9 per cent. on the figures for the preceding year in the number of bodies coming to autopsy, and it is gratifying to record that there has been a further reduction of just over 4 per cent., namely a total of 1150, as compared with 1200 in 1925.

Table I. shows the distribution of these month by month.

TABLE I.—Showing the Distribution of the Deaths month by month during 1926.

Month.	Mammalia.	Aves.	Reptilia.	Total.
January	16	39	17	72
February	18	41	13	72
March	32	58	25	115
April	28	35	25	88
May	26	41	22	89
June	28	36	25	89
July	33	43	30	106
August	24	41	41	106
September	25	46	36	107
October	38	33	26	97
November	26	51	21	98
December	22	63	26	111
Total	316	527	307	1150

Of the total 1150 there were 425 dying within six months of arrival in the Gardens, a percentage of 36·95. Six months constitute a somewhat long period to allow for acclimatization, but as this has for years been the custom, it must be retained for purposes of comparison. If we subtract these, the record shows that, whereas 828 *post-mortem* examinations were held in 1925 on animals which had been here more than the six months, this number is reduced to 725 in 1926. Since the new importations have been as numerous in 1926 as in the previous year, we may infer that the general health of the animals has been better.

TABLE II.—Showing the Distribution month by month of those dying within 6 months of arrival.

Month.	Mammalia.	Aves.	Reptilia.	Total.
January	7	5	9	21
February	3	11	7	21
March	6	15	10	31
April	6	8	9	23
May	4	6	12	22
June	5	7	19	31
July	9	13	23	45
August	10	14	29	53
September	12	13	29	54
October	18	10	18	46
November	16	17	14	47
December	3	21	7	31
Total	99	140	186	425

TABLE III.—List of the Chief Communicable and Preventable Diseases which have been met with in 1926.

Disease.	Mammalia.	Aves.	Reptilia.	Total.
Tuberculosis	38	13	3	54
Tuberculosis and Mycosis	11	19	—	30
Mycosis	8	48	9	65
Nocardiosis	3	—	—	3
Anthrax	2	—	—	2
Enteritis	20	82	26	128
Rickets (including Osteomalacia, etc.)	12	10	1	23
Pulmonary :—				
Capillary Bronchitis	16	27	25	68
Lobar Pneumonia	6	10	11	27

1. *Tuberculosis.* The total number of animals dying with tuberculosis (though this disease was not in every case the actual cause of death) is considerably greater this year than in 1925. An analysis of the cases shows that this increase is largely due to the fact that the disease took on an epidemic character among the inmates of the Monkey House. The spread of tuberculosis began towards the end of the first quarter, but the epidemic did not properly declare itself until the second. Thus, in the former, there were only two more cases than in the corresponding quarter of 1925, whereas in the period April–June inclusive there were

6 mammalian cases in 1925, but 22 in 1926. Of these 22, with two exceptions, namely a Wild Boar, "Rawley," and the Chimpanzee, "Daisy," all had been living in the Monkey House. Measures were taken in hand, and, in the third quarter of the year, there were only 4 mammalian deaths from this disease.

Though it is considered right to include under the heading of Tuberculosis all cases showing this infection at autopsy, in some of the animals this disease was not the actual cause of death. Thus a Black Lemur, Death Book No. 180/26, was also infested by Filariæ, and the immediate cause of death was hæmorrhage from a ruptured liver; a Rhesus Macaque, D.B. No. 233/26, and a Malbrouck Cercopitheque, D.B. No. 253/26, died of lobar pneumonia; an Axis Deer, D.B. No. 1004/26, from injuries inflicted by her companion and acute strangulation of the intestine in a ventral hernia; lastly, a Ringed-tailed Lemur, D.B. No. 548/26, with tuberculosis in a comparatively early stage. There was in this a growth at the base of the heart, extending thence to the bronchial and infraclavicular glands; there was œdema of the lung from pressure on the lymphatics and death resulted from this, or from cardiac failure due to pressure on the vagus nerve.

It is a matter, not only of interest, but of importance from the point of view of prevention, to ascertain, if possible, the portal of entry of the organism. This is not always easy to determine. Feeding experiments have shown that the bacilli may pass through the wall of the intestine, leaving no gross lesions, and by way of the lymphatics gain the lungs. Some argue that the oldest and best-developed lesions are found where the organism originally settled, producing there their maximum effect, but this begs the question rather than solves it, and in many of our cases here the disease is so widespread, often generalized, or runs so rapid a course, that it may be impossible to decide which is "the oldest and best-developed lesion."

With these reservations, as far as I could judge, of the 38 cases in Mammals the portal of entry seemed to be respiratory in 22, alimentary in 4; in the remaining 12 the disease was widely distributed, in fact generalized, at the time of death and the primary site was not determinable.

Three cases should receive special mention, not on account of there being anything of particular importance pathologically, but because of their historical interest. These three were "Rawley," the Wild Boar, "Daisy," the Chimpanzee, and "Sandy," the Orang-Utan.

The first had been in the Gardens since March 1919, that is, more than seven years. He was found to have advanced bronchopneumonic phthisis of the left lung, and scattered patches in the right. There were extensive pleural adhesions on both sides, more on the left, and from the latter the disease had spread to involve the pericardium. The bronchial glands were, of course, enlarged and caseous.

"Daisy" had been here since July 1923, and for some weeks prior to her death had been getting thinner, anæmic and lethargic, and was generally in a poor state. At the *post-mortem* examination she was found to have respiratory tuberculosis.

"Sandy" had been in the Gardens for more than six years; during the last two or three months of his life he had been losing flesh, had no appetite, and was generally "off colour." At his death there was found to be very widespread disease. The primary focus seems to have been the apex of the left lung. The bronchial glands were converted into bags of pus, one of which had ruptured into the right pleura. There next appears to have been invasion of the blood-stream with miliary generalization, and finally, by his swallowing the sputum, the intestine became involved.

There have been but 13 cases of uncomplicated Avian tuberculosis during 1926. In three of these the disease was very widespread, and the original portal of entry could not, consequently, be determined. It has been shown that in birds the alimentary route is the most common, owing to the fact that the disease in them is largely contracted by their swallowing material soiled by fæces containing numerous bacilli; and this is borne out by our findings here. Ten of the thirteen were definitely alimentary.

One case is of interest as an example of disease exceedingly widespread and of considerable duration without any objective symptoms. A Grey-headed Porphyrio was found dead in the Aviary. There was an abscess extending from the left ear forwards so as partly to occlude the eye. This contained cheesy pus with many tubercle bacilli. The air-sacs, anterior and posterior on both sides, were filled with tuberculous masses, forming practically a cast of each cavity; there were two deposits in the myocardium. The disease was equally extensive in the abdomen. As already mentioned, the posterior air-sacs contained caseous tuberculous masses; the serous coat of the intestine was covered throughout its length by milia, as was also the parietal peritoneum. The liver was studded with small caseous foci. The spleen was enlarged and nodular, with a mass of tuberculous material in the cortical region and deposits of varied size in the interior; finally, small tubercles were seen in the cortical areas of both kidneys. From the character of the lesions, some, at least, must have been of considerable standing, not the result of generalization shortly before death, yet nothing particular had been noticed as regards the health or appetite of the bird.

Reptilian tuberculosis, always of pathological interest, has been met with on three occasions, namely:—(1) An Æsculapian Snake, dying three months after arrival and showing tuberculosis of the lungs, liver, and spleen. (2) A Rough-eyed Cayman with extensive pulmonary tuberculosis—scattered foci with breaking-down contents—and signs of commencing generalization, the liver and spleen being dotted with milia. This animal had been

$4\frac{1}{2}$ years in the Gardens. (3) A Mexican Black Iguana, which died a week after arrival and had obviously brought the disease with it. The lungs were inflamed, but no macroscopic evidence of tuberculosis was present in these organs; behind the left lung was a mass as large as a walnut containing cheesy pus, and showing, microscopically, tubercle bacilli. There was no indication of intestinal disease, but in the absence of any pulmonary focus it is probable that the infection was acquired by the alimentary route, passing to the lymphatic vessels without causing any obvious lesion.

2. *Tuberculosis and Mycosis.* Certain cases, previously regarded as mycotic, proved on examination to be a mixture of this disease with tuberculosis. Hitherto the condition in which the air-sacs were seen to be lined by a readily-separable membrane, usually yellow or blackish in colour, has been diagnosed as mycosis; but on staining a section of this from a White-necked Stork, D.B. No. 399/26, numerous acid-fast bacilli were found, in addition to the mould (*Aspergillus fumigatus* was cultivated from it). Thereafter, I have made it a practice to examine all such deposits. There is no doubt that this precaution is in part responsible for the smaller number of cases of pure mycotic infection recorded.

In the majority of such, the mycotic condition appeared to be of longer standing and the tissues to have become the seat of tuberculosis secondarily. This being so, it is difficult, in some cases impossible, to state which was the actual cause of death, and it is considered advantageous, therefore, to place such cases in a separate category. During the year there have been 30 cases of dual infection, 11 amongst the Mammals and 19 amongst Birds; there have been no Reptilian cases.

These cases are of great interest pathologically; to describe them all would convert this report into a book, but the following may be cited as examples:—

(*a*) Three Wanderoo Macaques, D.B. Nos. 261, 270, and 285/26, all came to the Gardens on the same day and died on the 1st, 6th, and 10th of April respectively. All three showed widespread mycotic lesions of lungs, liver, spleen, and kidneys, sparse tuberculous lesions of the spleen in each case, and in the kidneys of the first, the liver of the second, and the lungs of the third. By methods of cultivation an Aspergillus was grown from all. Since in these animals the tuberculous infection was slight, if one can judge by the smallness of the lesions and the paucity of bacteria, and since in them tuberculosis usually runs a rapid course, whereas the mycotic growth is much more chronic, we may infer, as the most probable interpretation, that the mycotic infection was primary, the tuberculous secondary.

(*b*) A Mandarin Duck, D.B. No. 445/26, showed three caseous deposits in the left pectoral muscle, over which the skin was adherent and infiltrated with tuberculous growth. Both lungs were involved in a mixed tuberculosis and mycosis, as were also

the liver, spleen, and the left kidney. The ovary was very large, the size of a walnut, whitish in colour and consisting of a caseated mass of growth of mingled tuberculosis and mycosis.

3. *Mycosis.* There have been eight instances this year of mycotic disease in Mammals, namely two Wanderoo Macaques, two Pig-tailed Macaques, two Black Lemurs, a Hamadryas Baboon, and a Bennett's Wallaby. In one of the Pig-tailed Macaques the infection was not in an advanced stage; the animal fell and sustained a severe compound fracture of the humerus, and was chloroformed. The Wallaby had a mycotic pneumonia; in the Black Lemurs the intestinal tract and mesenteric glands were involved; in the others the disease was widespread, involving the lungs, liver, and spleen.

There is nothing particular to record concerning the 48 avian cases. So far as could be judged, 27 of these were of respiratory origin, 16 alimentary; four of the remainder appeared to be primarily cutaneous. There was extensive swelling with some pus-formation in the tissues of one or both feet, and the condition had spread to involve the bones of the foot and leg.

Nine cases have been met with amongst the Reptiles. This is considerably less than in 1925. In that year there had been a large number of Batrachia dying with the Monilia infection, the investigation into which was made the subject of a special paper communicated to the Society (P. Z. S. 1926, p. 683). There has been only one instance of this during 1926. Of the remainder, two are of sufficient interest to merit a few words. The first was a Yellow-spotted Lizard, which began to show cutaneous lesions soon after arrival in the Gardens. In spite of all treatment the disease spread over the body, and at the root of the tail there was a deep cellulitis with abscess-formation passing down to the spine, causing necrosis of the external surface of the vertebræ and communicating by sinuses with the exterior. The second was a Corn-Snake with numerous deposits in the lung, the kidneys (one of which was largely infiltrated and almost destroyed by the growth), and along the intestine, aggregated in some situations to form masses of considerable size and infiltrating the intercostal muscles.

The subject of Mycosis was deemed to be of sufficient importance to warrant special study in view of its apparent increase, amongst Mammals in particular. With the permission and assistance of Dr. Vevers, I obtained samples of the various forms of grain etc. supplied to the animals, both birds and mammals, namely oats, wheat, millet, canary-seed, maize, bran, and biscuit-meal. Samples were carefully taken from their separate bins. By methods of cultivation on maltose-Sabouraud medium certain moulds were isolated: Aspergillus from the oats and biscuit-meal, and a peculiar Mucor with black fructification from the millet and the maize. The wheat, bran, and canary-seed yielded no growth.

Dr. Vevers next kindly obtained for me some samples of these

same grains as they came from the factors, and before they were placed in the storage-bins. The moulds were not obtained from cultural experiments put up with these.

Seeing that the cultures made from the lesions of several animals dying from Mycosis yielded varieties of Aspergillus, namely *A. glaucus*, *A. fumigatus*, and *A. niger*, it appeared probable that infection, though being conveyed from animal to animal by contact or inoculation of wounds from the ground infected by food and fæces, was being constantly re-introduced by the contaminated food. Thorough cleansing of the bins has been followed by a marked reduction in the number of cases. From 30 in the first quarter and 28 in the second, the figures have fallen to 25 in the third and to 14 in the last three months.

4. *Nocardiosis.* There have been only three cases this year of the Nocardial infection of Wallabies which proved so fatal in 1925. All these were Bennett's Wallabies, and in all the jaw and facial muscles were involved. There is nothing in particular to record concerning these, except the fact that they had been kept in the Sanatorium under observation for several weeks on first arrival. They were then transferred to the Park Paddocks. The question of the food appears not to enter in these cases, since the spiky food which probably caused the disease in the preceding year, and as has been fonnd to be the cause elsewhere, had not been given. The previous cases had, however, been moved to the Park Paddocks, and it may be surmised that these paddocks have become fairly extensively infected, and that these later importations, though free from disease on arrival and while under observation in the Sanatorium, contract infection after transfer.

5. *Anthrax.* Two instances of this occurred, one on December 24th, the other on December 29th. Although the investigations in connection with these were not completed till some time in January, it is considered more satisfactory to place them on record in this 1926 report, because the work in connection therewith refers to deaths occurring that year.

The two cases were female Indian Elephants (*Elephas maximus*), D.B. Nos. 1122/26 and 1139/26. The first had been in the Gardens since July 1920, the second since February 1922. The illness in each case began, apparently, somewhat abruptly with shivering, but this was not marked; the animal did not take its food well and was clearly out of sorts. Without exhibiting any distinct symptoms, the general condition became worse, and, in the first case, in about 36 hours from the onset of symptoms, the animal seemed unwilling, if not actually unable, to rise, and was found dead the following morning, some 48 hours after the onset. Death had probably taken place early in the night, for the body was quite cold when the autopsy was performed early the next morning.

The second showed very similar symptoms, being taken ill on December 27th. As she seemed to be weak, stimulants were

given, and on the evening of the 28th she seemed to be considerably better and took food. This amelioration was, however, very transient, and she died the next day. The autopsy was begun as soon after as possible; the body was quite warm and rigor mortis had not set in.

A detailed account of the *post-mortem* findings need not be recapitulated; they are given in the autopsy records which are kept of each case and can be seen by anyone interested. Suffice it to say that the blood was dark and unduly viscid, but the muscles did not—this was a strange fact—show any unusual discoloration. Another, perhaps less uncommon, anomaly was that the spleen, though congested and very dark, was not enlarged. The other organs revealed macroscopically nothing particularly noteworthy, except for the dark colour of the contained blood, and, in the first case, "Indiarani," a frothiness or foaminess of the viscera, especially the liver.

In view of the investigations carried out and of the after events, it will be simpler to deal with the two cases separately.

From the first, "Indiarani," smears were taken from the heart-blood, the peripheral blood, the liver, spleen, and lungs, and cultures were put up from each of these. Since the liver on section showed the foaminess which was suspected to be due to Welch's bacillus, *B. ærogenes capsulatus*, the cultures were set up in duplicate and incubated aerobically and anaerobically. Portions of the liver, spleen, and lungs were also taken for histological examination.

All the smears showed large, rather square-ended bacilli, and the anaerobic cultures grew well, but the aerobes did not; I was therefore led to infer that the *B. ærogenes capsulatus* was the cause of the condition. I have heard since, from Professor Wooldridge and others, that the gas-gangrene bacilli very rapidly kill out the *B. anthracis*, with the result, at the time very puzzling, that the latter do not grow in the presence of the former. Thus the fact is accounted for that Welch's bacillus, an anaerobe of the gas-gangrene group, developed to the exclusion of the other.

In the case of the second elephant, "Sundermalah," the conditions found at autopsy were, with the exception that the foamy state of the liver was absent, identical with what had been noticed in the former case, but, in addition, on the internal aspect of the right elbow there was a sore, the size of a crown piece, covered by a scab. This scab was carefully raised and smears were made from the tissue beneath and at its edge, and enormous numbers of anthrax-like bacilli were seen on staining.

Similar smears, cultures, and tissues for section were taken as in the first case, and, in addition, cultures from the sore on the elbow. This time the aerobic growth was copious, and was definitely characteristic of Anthrax, confirming what had been suspected from examination of the smears.

Briefly, the tissues which have been cut and stained show the condition very clearly.

In neither case did the intestine show any inflammation, and the probability of the infection having taken place by the mouth was slight. Sections of the liver, moreover, in parts show clearly that the portal venules contain practically no bacilli, some none at all, others a few which might be transferred thither in making the section, whereas branches of the hepatic artery contain many, some being very full. The only satisfactory explanation that occurs to me for this is that the systemic vessels carried the infection from the skin or the lungs, and that infection did not gain entrance *via* the alimentary tract.

In spite of the absence of signs of intestinal infection, Dr. Vevers suggested that the oil-cake supplied to the elephants should be examined bacterially. It was quite possible that the oil-cake might be trodden upon and crushed, and any surface-wound become infected by the animal lying on it, if it were contaminated.

The feet were carefully examined, but in neither of the elephants was there any sore found thereon. It was, of course, impossible to examine the whole of the oil-cake, but several cultures were put up from samples taken at random from the box in which it was kept and from the dust at the bottom, but with negative results.

On January 1st the remaining five elephants were examined, and at Dr. Vevers's suggestion and with his help cultures were made from some of the fissures present in their skin, on the slender chance of discovering a local infection in any of them, or a possible deposition of the bacilli prior to infection; but all proved negative and all remain well at present.

Another suggestion, for which again I am indebted to Dr. Vevers, was that the Pig-oil with which the elephants (it is used also for other animals) are rubbed from time to time, and they had in fact been rubbed on December 18th, might be contaminated. Cultures were accordingly put up from the few drops remaining in the tin which had been used, and also from a tin freshly opened for this purpose. The latter proved to be quite sterile, and from the first no harmful organisms were grown, merely such as might gain entrance from exposure to the air. There were no anthrax colonies. Other cultures put up later only served to confirm these results.

So much for the Elephant side of the question. By the 30th December all we could state definitely was that the elephant, "Sundermalah," had died from Anthrax; in the case of "Indiarani" the verdict was Not Proven, although the probabilities were almost overwhelming.

Turning now to the Human aspect. On December 30th, by reason of the results of the examination of the smears and cultures from "Sundermalah," all those who had been in contact with

either of the cases were carefully examined for any cuts, sores, abrasions, etc. Four men, whom we will designate as A, B, C and D, were found to have small cuts or fissures on their hands, and another, E, a spot with a dark centre on the face. Smears and cultures were made and examined from each of them. From B and C there grew colonies of *Staphylococcus albus* only; from A, *Staphylococcus albus* and *St. aureus*; from E, the same two forms together with some colonies of *St. citreus*. This last had several acne spots on his face, and the one examined had been pustular. The patient had opened it and expressed the pus *before* the date of the first autopsy, and the suspected spot proved to be merely a drying-up acne pustule. Subsequent examinations were made because of the suspicion of the black crust, but the results were always negative and no further development took place in his case. D had cut his finger at the second autopsy, but had immediately ceased to take further part in it, and had had the wound treated with antiseptic and bandaged. He showed no further signs, and the culture in his case proved sterile.

On January 3rd, 1927, the man B came up again, showing a sore on his wrist which had started in a hair-follicle. This was a papule becoming vesicular, with a hæmorrhagic border, the whole being a little smaller than a threepenny-piece. A culture was made from this and also smears. The latter showed anthrax-like bacilli on staining. He was at once sent to hospital, and the culture which had grown abundantly by the succeeding morning confirmed our suspicions. On the instructions of Dr. S. Monckton-Copeman, F.R.S., the original culture was sent to Dr. Arthur Eastwood, the Bacteriologist to the Ministry of Health, who wrote to me stating that he had proved the fact that the organism was the *B. anthracis*.

This patient, B, had not come in contact in any way with the second elephant, but with the first only; we thus have the final proof, which, up to that time, was wanting, that the first case had been one of Anthrax—the suspicion was replaced by certainty. B had first noticed the spot on December 30th or 31st, thus giving an incubation period of 6–7 days.

On January 5th, 1927, the man C, who had had a great deal to do with the second autopsy on December 29th, 1926, called attention to a small red spot on the extensor aspect of his fore-arm, which he had noticed on the previous evening, January 4th There was another, similar, spot about 3 inches above this one; both were hair-follicle lesions. Serum from these was examined by smear and revealed *B. anthracis*, a fact which was confirmed by a copious growth obtained from the fluid by the following morning, the culture having been put up at the same time as the smear. He also was sent at once to hospital and the culture forwarded to Dr. Eastwood as before, who again confirmed our work. The time which had elapsed between the second autopsy and the appearance of the spots was, in this instance also, 6½ days.

Later on the same day, Jan. 5th, another individual, F, who

had handled the remains for carting them away, presented himself with a sore on his arm which, he stated, had appeared on the previous day (six days after the second autopsy). When seen by me it was very small, hardly, if at all, larger than a hempseed, and it had a slight œdematous periphery. This was probably part of the actual anthrax lesion, but the patient said that he had the same morning been "squeezing the place to get the stuff out," and some of the swelling may have been due to this. Smears from it showed the bacilli in considerable numbers, and this patient was sent at once to hospital to join the others. The culture by next morning abundantly confirmed the findings of the direct smear.

The following day, Jan. 6th, another man, G, presented himself with a "boil" on his right forearm, which according to his history, he had had for the preceding "two or three days." There was a definite lymphangitis extending from this up the arm, and, in contradistinction to the "spots" in the other patients which were quite painless, this "boil" was exquisitely tender and painful. Smears were examined from the serous discharge at the border of the inflamed cellular tissue, but only Staphylococci and Streptococci were seen. To be on the safe side, however, cultures were also made, and he was given the option of having an injection of anti-anthrax serum, which he accepted. The following morning there were colonies developed of all three organisms, Staphylococcus, Streptococcus, and *Bacillus anthracis*, and this patient, making the fourth, was at once transferred to hospital.

There have been no further cases, so far as I am aware, in connection with these occurrences at the Gardens, either among the animals or among the human contacts.

In concluding this question, I would emphasize the following three points as being of particular interest:—

(1) That infection may readily occur *via* a hair-follicle when every care has been taken to disinfect and seal all cuts, fissures, or open wounds. The fact that, in each case, the forearm was the site of the anthrax-pustule, indicates that arms as well as hands should be thoroughly cleansed after an autopsy where splashing may occur or blood may dry.

(2) That the period of incubation is six and a half days, as evidenced by two of the cases very definitely, B and C, while F's lesion arose at the same interval after the second autopsy. In the case of the patient G, nothing as regards the incubation-period can be inferred; he might have become infected at any time after the death of the first elephant, and the anthrax developed at the site of a forming abscess. According to the text-books, the incubation-period of the cutaneous anthrax, or malignant pustule, varies from "a few hours to three or four days." Our cases do not agree with this.

(3) That the initial sore is quite painless and, being unaccompanied by any symptoms of constitutional disturbance,

might easily be overlooked. The text-books state that the initial lesion is "a small red nodule, surrounded by reddish-blue blisters containing clear or blood-stained fluid . . . accompanied by a sensation of burning and intense itchiness." One of the patients, C, said that there was a slight smarting when he touched or pressed the spot; otherwise there was no pain, itching, or discomfort of any kind, and, with the exception of G, who had a definite boil with lymphangitis, none complained of any pain whatever, nor was there any swelling or tenderness of the neighbouring lymphatic glands.

6. *Enteritis.* This disease continues to take a heavy toll, but there is a tendency to improvement in this respect. Thus in 1925 there were 165 deaths ascribed to the condition, *i.e.* a percentage of 13·7; in 1926 there were 128, or a percentage of 11·1 of the total deaths. A matter for congratulation is that amongst the Mammalia the numbers have been considerably reduced; in place of 57 in 1925 there have been only 20 this year.

The subject of enteritis and its investigation is one of bewildering intricacy. Much work has been done upon it during 1926, of which only a few points can be touched upon here. From the aspect of comparative pathology the interest often lies, not so much in the similarities, as in the points of difference between the results of infection of Man and of Animals by certain organisms. Further, in the remarks put forward in this record, I would wish it to be definitely understood that, though the various organisms isolated in different cases were very possibly, in some cases highly probably, causative of the disease in question, the fact of the ætiological relationship to the pathological condition found is incapable of proof in the absence of experimental work, from which I am debarred. With this reservation, the following are certainly of considerable interest. From some animals an organism has been isolated once only; the evidence in favour of these being causative is, therefore, in the absence of experimental work too slight to be worthy of record; but where the same organism is isolated in pure culture from several animals, and closely similar, even identical, pathological conditions are found in them, the probabilities of the relation of cause and effect are of greater weight, even though the final proof of experimental confirmation is wanting. These latter only will therefore be spoken of here.

(1) An organism giving the morphological, cultural, and fermentative reactions of a *Paradysentery bacillus of the Flexner type* was isolated in the following cases:—

(*a*) A Canadian Beaver, D.B. No. 189/26, in which at autopsy there were found several ulcers in the large intestine, more numerous in the cæcum than elsewhere. There were a few also in the lower part of the small intestine. Three of the ulcers in

the large intestine had perforated; two were sealed by lymph, the third was pouring the bowel-contents into the peritoneal cavity, and death resulted from peritonitis.

(*b*) The Gorilla, John Daniel II., which was not resident in the Gardens at the time of its death, but whose case is included here on account of (i.) its pathological interest; (ii.) the fact that it had been on exhibit for some months here; (iii.) the autopsy had been carried out at the Prosectorium. This animal had suffered from intestinal disturbance for some time, and during the last few months preceding its death lost 42 lbs. in weight.

The chief macroscopic findings were a general anæmia, marked emaciation, and a follicular and ulcerative colitis.

In both the above, agglutination of the organism was obtained in dilutions up to 1 : 900 in the former, and 1 : 1200 in the latter with anti-Flexner serum.

(2) The following three cases amongst Birds may be mentioned together. From a Westermann's Cassowary (D.B. No. 931/26), an Ostrich (D.B. No. 1037/26), and a Black-headed Caique (D.B. No. 940/26) a bacillus was grown having the same morphological, cultural, and fermentative characters. The morbid features in the intestine revealed at autopsy may be briefly stated: In the first there was an acute inflammation of the mucosa throughout, from the duodenum to the cloaca, but no ulceration; the third exactly resembled this one, while the second showed an almost uniform, reddish-purple congested mucosa in the small intestine, analogous to, but rather more severe than, that of those just mentioned, but, in addition, the mucosa of the large intestine was covered in confluent patches by a false membrane over a considerable area.

From all three a motile bacillus, Gram-negative, was isolated from the liver-pulp, bile (where the gall-bladder was present), portal blood, and spleen, and, in the two former, from the systemic blood also. This bacillus fermented dextrose, maltose, mannite, and saccharose, with the production of acid but no gas, caused no change in lactose or dulcite, produced indol and a feeble clot in milk. In the Ostrich, which had the pseudomembranous inflammation of the large intestine, there was isolated also a motile bacillus fermenting the same sugars, but with the production of gas (acid and gas in dextrose, maltose, mannite, and saccharose; no change in lactose or dulcite), and producing no indol nor any clot in milk, though the reaction of the last becomes acid.

(3) *Bacillus fæcalis alkaligenes.* This has been isolated in several instances. It is an organism which, as far as I can find from examination of the literature at my disposal, has not been recorded as fatal to Man, though cases of septicæmia due to it have been noted. The fact that the morbid appearances were practically the same in each case, differing only in degree and that but slightly, enhances the interest of the findings. Briefly, the conditions presented in the intestine at autopsy were those

of acute congestion and inflammation, the mucosa being swollen, of a deep red colour, in parts almost purple; in others the whole tract from pylorus to cloaca was of a uniform deep brick-red colour, with swollen, œdematous, boggy-looking mucous membrane. In one only were there two or three small ulcers high up in the small intestine; these were associated with and very possibly due to the presence of nematodes. The remarkable characteristics of all (with this one exception) was the total absence of any ulceration in spite of the severity of the inflammation. Once (in a Puff Adder) over the lower 4–5 inches above the cloaca there was the development of a patch of false membrane.

This condition has been met with, in addition to the Puff Adder mentioned, in the Ground-Tortoise (twice), the Leopard-Tortoise (also twice), and an American Plate Lizard. The only instance in which the organism was isolated from animals other than reptiles was a Levaillant's Amazon, D.B. No. 878/26, in which the mucosa of the intestine was throughout acutely congested and inflamed, of a deep uniform red, almost plum-coloured, the wall swollen, œdematous, and showing numerous petechiæ, but no actual ulceration.

(4) Six Lion cubs were born about the middle of June; four of these were removed from the mother, but did not live long, the cause of death being apparently inanition and debility. The remaining two were fed entirely by the mother, but these also died within a week. At the *post mortem* each showed several punched-out ulcers in the duodenum, intense inflammation of the mucosa, the actual cause of death being an intestinal hæmorrhage from one of the ulcers. Cultures made from the bile, the blood, and from the deeper parts of some of the ulcers resulted in the isolation of a hæmolytic Streptococcus, in pure culture from the blood and bile, and mixed with other organisms in the case of the ulcers. The only source from which we could conjecture the infection to have arisen was the teats of the mother.

Two other organisms were isolated in several instances, each associated with a definite pathological state. Others were isolated only once or twice and will not be detailed here, as the probability of their being causative is less certain.

(5) There have been several deaths in the Small Bird House, particularly in the latter part of the year, the birds all showing degrees of the same condition, namely an enteritis of a congestive, catarrhal character, without ulceration, and not associated with the presence of any parasites.

On opening the body the intestines were noticed to be of a deep red colour, and the vessels of the mesentery engorged. When the intestine itself was opened, the mucous membrane was seen to be very inflamed, swollen, œdematous, and the contents thin or grumous, yellowish-white, or gamboge-coloured, custard-like, and in the most acute cases slightly tinged with blood. There was in no case any ulceration; the contents, apart from food-débris, consisted of shed mucosa-cells with an excess of leucocytes.

In several cases the bodies were not sufficiently fresh for bacterial investigation to give any hope of success, but, in those that were, attempts at culture were made from the depths of the mucosa, from the liver, the spleen, the blood, and, in some cases, where the lungs showed a capillary bronchitis from these organs also.

From them there grew a Gram-negative diplococcus, which fermented none of the laboratory sugars, and, in morphology and absence of fermentation, resembled the *Micrococcus catarrhalis*.

Without venturing so far as to state that this organism was the actual cause of death in these birds, it is worthy of remark that this coccus, which is one of those responsible for acute catarrh in Man, should be found in a considerable number of cases of acute intestinal (and sometimes pulmonary) catarrh in small birds. Though cultivation was attempted from birds dying elsewhere, only in those from the Small Bird House was this organism isolated. Though infection with the *M. catarrhalis* never terminates fatally in Man, except by preparing the way for, or being associated with, other organisms, it is quite possible that in these small birds the toxin produced, aided by the exhausting diarrhœa which accompanies it, may be sufficient to cause death.

(6) Lastly, there have been many cases in the Reptile House, at certain times occurring so closely together as to constitute an epidemic on a small scale, at others at an interval which led the Curator and myself to infer that infection had taken place from animal to animal, probably by food contaminated by the fæces of other cases.

All suffered from an obstinate diarrhœa, sometimes blood-tinged, for a few days before death, and at autopsy showed an acutely inflamed intestine, especially towards the lower part. Terminating at, or a little above, the cloaca, and extending up for 3·4 inches, occasionally even more, the mucosa was covered with an adherent, ashy-grey false membrane, leaving on removal a bleeding surface. The wall of the intestine was thickened and very inflamed. In three cases, where the illness had lasted for a longer period than in the others, small grey foci were present in the liver, and examination after staining sections of this viscus revealed that these were abscesses forming, or already formed, secondary to the intestinal condition.

This membranous form of enteritis has been met with in :—

Name of Animal.	Date of Death.
Exanthematic Monitor *	4. 9.1926.
Nile Monitor	9.10.1926.
Nile Monitor *	11.10.1926.
Exanthematic Monitor	10.11.1926.
Exanthematic Monitor *	16.11.1926.
Exanthematic Monitor	20.11.1926.
Nile Monitor	9.12.1926.
Nile Monitor *	14.12.1926.
Nile Monitor *	14.12.1926.
Nile Monitor *	20.12.1926.

In every instance where the body was sufficiently fresh, cultures were put up from the portal blood, the liver, the small foci when present, the spleen, and the depth of the mucosa, and in those marked with an asterisk an organism was grown giving in each case the same morphological and cultural characters, namely an actively motile bacillus, not retaining the stain by Gram's method, fermenting dextrose, maltose, mannite, and (sometimes more slowly) saccharose, with the production of acid and gas, having no action on lactose or dulcite, rendering milk acid, but not forming any clot, and usually producing indol in four to five days.

7. *Rickets, Osteomalacia, Osteoporosis.* There is little to say on this subject. Amongst the mammals there have been fewer cases coming to autopsy, namely 12 in place of 17 the previous year; in Birds, however, the number is greater. Two of the mammalian cases were a Rhesus Macaque and a Common Macaque, dying quite young from tuberculosis; the rachitic condition was in an early stage.

Of the Avian cases two were Kestrels which had been in the Gardens only five or six weeks; one was heavily infested with worms, and the disease was probably present on their arrival. Three others were Budgerigars, bred in the Gardens only a month prior to their deaths. They are included under this heading on account of the softness and pliability of the bones. There were none of the common rachitic deformities present.

Lastly, there has been included one Reptilian case. This was a Hilaire's Terrapin, resident here for four years. The bones were soft and the plastron and carapace very pliable; they could be bent in any direction like wet cardboard. There were an associated severe anæmia and a general hydræmic state of the blood and tissues.

8. *Cage Paralysis.* At the suggestion of the Superintendent, Dr. G. M. Vevers, investigations were taken in hand by Dr. Beattie and myself to elucidate, if we could, the question of Cage Paralysis and the morbid changes which underlie it. We have been able to study three cases of this condition, and have found closely analogous, one might say identical, pathological changes in certain parts of the spinal cord, the differences being in degree only, not in kind. The subject is too lengthy and complicated a one to describe in detail here, but we hope to communicate our findings later as a separate paper to a Scientific Meeting of the Society, if an opportunity is afforded us. Briefly, we may say that so far as the history and the pathological changes in so few cases warrant any expression of opinion, the condition appears to be, or is closely allied to, Anterior Poliomyelitis of the chronic type, as seen in Man.

9. *Rideal-Walker* tests have been carried out on four disinfectants during the year.

As in 1925, so throughout the year under review, blood-smears have been made from all the animals submitted to autopsy, for the purpose of examining for the presence of protozoal parasites. Slides are also sent to Dr. C. M. Wenyon, who furnishes a report quarterly for inclusion with my pathological records. The following list of the parasites found and the hosts in which they were present will be of service to future investigators, particularly when taken in conjunction with the similar report for 1925:—

Single Infections.

Parasites.	Hosts.
Cingula	*Causus rhombeatus.*
Endotrypanum schaudinni	*Cholopus didactylus.*
Globidium	*Macropus bennetti.*
Hæmogregarines (107)	*Ancistrodon piscivorus*; *Bitis arietans*; *Boa constrictor* (2); *Boa imperator*; *Bufo mauritanicus*; *Callopistes flavipunctatus*; *Calotes mystaceus* (2); *Cerastes vipera*; *Chamæleon senegalensis* (2); *Chlorophis irregularis*; *Chrysemis belli* (2), *Chrysemis picta*; *Clemmys insculpta*, *Cœlopeltis monspessulana*; *Coluber corais*; *Coluber guttatus*; *Coluber leopardinus*; *Coluber obsoletus* (2); *Corallus caniscus*; *Coronella austriaca*; *Coronella getula* (2), *Coronella getula* var. *boylii*; *Crotalus atrox*; *Crotalus cerastes* (2); *Crotalus confluentus*, *Crotalus durissus*; *Crotalus exsul* (2); *Crotalus mitchelli*; *Crotalus oregonus* (2); *Crotalus scutellatus*; *Ctenosaurus multispinis* (3), *Cyclemys amboinensis* (2); *Dipsadomorphus dendrophilus* (2); *Drymobius boddaerti* (2), *Elaps tschudii*; *Emys orbicularis*; *Eryx jaculus* (2), *Eunectes murinus*; *Heterodon simus*; *Lacerta ocellata* (4); *Naia bungarus*; *Naia tripudians* (5), *Python reticulata* (3), *Python sebæ*, *Python spilotes*; *Rhinochilus lecontei*; *Salvadora*, *Testudo berlandieri*; *Testudo ibera*; *Tropidonotus fasciatus* (3); *Tropidonotus fasciatus* var. *sipedon*, *Tropidonotus hammondi* (5); *Tropidonotus viperinus*; *Tupinambis nigropunctatus*; *Uromastix hardwickii*; *Varanus bengalensis*, *Varanus exanthematicus* (2); *Varanus griseus* (2); *Varanus niloticus* (6); *Zamenis dahli* (2); *Zamenis diadema* (4); *Zamenis flagelliformis* (2); *Zamenis tæniatus* (3).
Hæmogregarines or Coccidia	*Iguana tuberculata.*
Hæmoproteus (26)	*Asturinula monogrammicus*; *Balearica pavonina* (3); *Balearica pavonina cecilia* (2); *Centropus rufipennis*; *Cerchneis tinnunculus*; *Coracias caudatus*; *Estrilda cinerea*; *Fringilla cœlebs*; *Lamprotreron superba*; *Loriculus galgulus* (3); *Lorius flavopalliatus*; *Lorius garrulus*; *Paradisea raggiana*; *Psophia crepitans*; *Ptilopus superbus*; *Pyromelana franciscana*; *Pyrrhula pyrrhula*; *Scops leucotis*; *Tympanistria tympanistria*; *Tyto arfaki*; *Xantholæma hæmatocephala*.

PARASITES.	HOSTS.
Hexamita (4)	*Chamæleon senegalensis*; *Cistudo carolina*; *Lophortyx californica*; *Testudo ibera.*
Leucocytozoon (17)	*Bucorax abyssinicus*; *Carpodacus purpureus*; *Coturnix coromandelica*; *Francolinus pondicherianus*; *Gallus gallus*; *Ibis molucca*; *Nucifraga caryocatactes* (3); *Podargus cuvieri*; *Pyrrhula pyrrhula*; *Schizorhis leucogaster* (2); *Scolopax rusticula*; *Scotiaptex lapponica*; *Tragopan satyra*; *Turtur turtur.*
Piroplasma	*Procyon lotor.*
Plasmodium præcox (8)	*Aptenodytes patagonica*; *Neotis denhami*; *Pternistes nudicollis*; *Rhopodytes tristis*; *Serinus hortulanus*; *Serinus icterus*; *Spreo superbus*; *Syrmaticus reevesi.*
Plasmodium præcox or Hæmoproteus (infection scanty; difficult to determine which of these is present).	*Asturinula monogrammicus*; *Barnardius semitorquata*, *Cursorius temmincki*; *Munia atricapilla.*
Plasmodium pteropi	*Pteropus medius.*
Plasmodium vasali	*Callosciurus prevosti* (2).
Plasmodium sp. ?	*Iguana tuberculata* (3).
(Sarcocystis)	(*Macropus bennetti.*)
Selenomonas ruminantium	*Tragulus javanicus.*
Trichomonas	*Anthropoides virgo*, *Trachysaurus rugosus.*
Trypanosoma sp.	*Caccabis chukar*; *Icterus spurius.*
Filarial embryos (21)	*Agapornis lilianæ*; *Cercopithecus mona* *Chasmorhynchus nudicollis*; *Eurystomus orientalis* (2); *Grammatoptila striata*; *Lamprocolius chalybeus*; *Lanius lahtora*; *Lemur macaco*; *Nycticebus tardigradus*; *Oriolus galbula*; *Paroaria cucullata*; *Physignathus lesueuri* (3); *Rana catesbiana*; *Spilopelia tigrina*; *Sporægınthus melpoda*; *Tamaulipas grega*; *Tupinambis nigropunctatus*; *Uromastix acanthinurus.*

DOUBLE INFECTIONS.

Coccidia and Globidium	*Macropus bennetti.*
Hæmogregarines and Lankesterella.	*Rana tigrina.*
Hæmogregarines and Filarial embryos.	*Ctenosaura multispinis*; *Dracæna guianensis.*
Hæmoproteus and Filarial embryos.	*Columba guinea.*
Leucocytozoon and Filarial embryos.	*Gallus sonnerati.*
Plasmodium præcox and Hæmoproteus.	*Aidemosyne cantans*; *Bubo poensis*; *Cardinalis cardinalis*; *Crateropus bicolor*; *Melophus melanocephalus*; *Nothura maculosa*; *Tympanistria tympanistria.*
Plasmodium præcox and Filarial embryos.	*Petrophila cinclorhyncha.*

Triple Infections.

Parasites.	Hosts.
Hæmogregarines, Trypanosoma rotatorium, and Lankesterella.	*Rana tigrina.*
Hæmoproteus, Leucocytozoon, and Filarial embryos.	*Ammoperdix heyi.*
Plasmodium præcox, Hæmoproteus, and Filarial embryos.	*Sialia sialis.*
Plasmodium præcox, Hæmoproteus, and Leucocytozoon.	*Columba grisea*; *Megaloprepia magnifica.*

Quadruple Infection.

Hæmogregarines, Trypanosoma rotatorium, Laskesterella, and Filarial embryos.	*Rana tigrina.*

Quintuple Infection.

Hæmogregarines, Trypanosoma rotatorium, Hexamita, Lankesterella, and Filarial embryos.	*Rana tigrina.*

The findings as detailed above may be epitomized as follows:—

Single Infections have been met with in 204 *instances*, namely:—

Hæmogregarines	107
Hæmoproteus	26
Filarial embryos	21
Leucocytozoon	17
Plasmodium præcox	8
Plasmodium præcox or Hæmoproteus*	4
Hexamita	4
Plasmodium sp.?	3
Plasmodium vassali	2
Trichomonas	2
Trypanosoma sp.	2
Cingula	1
Endotrypanum schaudinni	1
Globidium	1
Hæmogregarines or Coccidia*	1
Piroplasma	1
Plasmodium pteropi	1
Sarcocystis	1
Selenomonas ruminantium	1

Double Infections have been met with in 14 *instances*, namely:—

Plasmodium præcox and Hæmoproteus	7
Hæmogregarines and Filarial embryos	2
Coccidia and Globidium	1
Hæmogregarines and Lankesterella	1
Hæmoproteus and Filarial embryos	1
Leucocytozoon and Filarial embryos	1
Plasmodium præcox aud Filarial embryos	1

Triple Infections have been met with in 5 *instances*, namely:—

Plasmodium præcox, Hæmoproteus, and Leucocytozoon	2
Plasmodium præcox, Hæmoproteus, and Filarial embryos	1
Hæmogregarines, Trypanosoma rotatorium, and Lankesterella.	1
Hæmoproteus, Leucocytozoon, and Filarial embryos	1

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* Present in very small numbers and not sufficiently distinct to enable a definite diagnosis to be made.

Quadruple Infections with

Hæmogregarines, Trypanosoma rotatorium, Lankesterella, and Filarial embryos; and

Quintuple Infection with

The same four plus Hexamita

have each been met with once.

Apart from the various conditions which have called for special investigation and research and which have been detailed in the foregoing pages, a number of subjects of pathological interest have been encountered in the course of the routine autopsies carried out during the year.

A list will first be given of some of the treasures which the mine of pathological wealth at the Prosectorium has yielded during the year, and from this list a few of surpassing interest will be selected for further brief description.

These last are marked with an asterisk.

1. *Intestinal Obstruction.*
   - (*a*) *Rock Wallaby.* Intussusception of the colon, 9 inches in length, 3 inches protruding from the anus. Hæmorrhage also from rupture of mesenteric vein.
   - (*b*) *Mona Cercopitheque*, D.B. No. 57. Internal hernia.
   - (*c*) *Common Macaque*, D.B. No. 473. Colic intussusception.
   - (*d*) *African Civet-Cat*, D.B. No. 699. Iliac intussusception.
   - (*e*) *Tasmanian Devil*, D.B. No. 784. Colic intussusception, some 12 inches have passed in and 2–2½ are protruding at the anus, with much hæmorrhage.
   - (*f*) *Common Marmoset*, D.B. No 785. Iliac intussusception, 1 inches gangrenous. Intussusception contains several worms.
   - (*g*) *Nile Monitor*, D.B. No. 934. Lower 6-7 inches purple from strangulation due to intussusception, and the bowel is filled with blood.
   - (*h*) *Arctic Fox*, D.B. No. 990. Ileo-colic intussusception, associated with large numbers of nematodes.
   - (*i*) **Axis Deer*, D.B. No. 1104. Strangulated ventral hernia.
2. *Intestinal Perforation.*
   - (*a*) *Porose Crocodile*, D.B. No. 13. Perforation of cloaca, with general peritonitis. Cause not discovered.
   - (*b*) *Two-toed Sloth*, D.B. No. 125. Perforation of intestinal ulcer producing general peritonitis. Eight weeks in the Gardens. Cause again not discovered; the animal had been fed only on fruit, leaves, and such-like.
   - (*c*) *Nyasa Love-bird*, D.B. No. 163. In this case the perforation was associated with and apparently due to cestodes, reported by Professor Leiper as a species of *Moniezia*. One of them was free in the pus in the abdominal cavity, the result of the peritonitis set up, while another was found partly inside and partly outside the intestine at the site of the perforation.
   - (*d*) *Canadian Beaver*, D.B. No. 189. The peritonitis in this case was due to perforation of an intestinal ulcer. There were many ulcers in various stages.
   - (*e*) *Asiatic Jackal*, D.B. No. 229. Perforation of a duodenal ulcer.

(*f*) *Rass.* A case of nemesis, the result of greed. Fish was given to Conger Eels in the same tank; this Rass seized upon it, and some of the bones perforated the intestine low down, causing death.

(*g*) *Common Boa*, D.B. No. 385. There was an acute enteritis and a perforation of considerable size producing peritonitis and the formation of a large abscess-cavity between the intestine and the body-wall.

(*h*) *American Tapir*, D.B. No. 552. Died suddenly; an hour or so previously it had appeared to be quite well. Both lungs were studded with new growth. There were nematode larvæ and balantidial cysts in the fæces; shallow ulcers were present in the rectum and a small one, which had perforated, in the duodenum.

(*i*) *Glossy Ibis*, D.B. No. 657. A foreign body, a nail, had penetrated from the gizzard or intestine to form an abscess in the abdominal muscles. This bird had been in the Gardens only 10 days, and the condition must have arisen prior to its arrival, because the nail was thickly coated with inspissated fæcal matter and no signs of perforation could be found.

(*j*) * *Spotted Hyæna*, D.B. No. 672.

(*k*) *Reindeer*, D.B. No. 803. There was a small ulcer in the reticulum, possibly due to a sharp oat-grain. The ulcer had perforated, and was plugged by a deposit of lymph and pus. Leakage, however, had led to a large deposit of purulent lymph between the liver and the diaphragm and to a general peritonitis. Over 5 litres of purulent fluid were measured. This animal had been 1½ years in the Gardens and was thought to be old on arrival.

3. *Neoplasms.*

(*a*) **Brindled Gnu*, D.B. No. 156.

(*b*) **Rhinoceros*, D.B. No. 340.

(*c*) **Otter*, D.B. No. 408.

(*d*) *Porose Crocodile*, D.B. No. 449, showing a sarcomatous growth of the heart, brain, and liver. Reported in the 'Journal of Pathology and Bacteriology,' Jan. 1927, vol. xxx. no. 1.

(*e*) *Hamster*, D.B. No. 453. Over two years in the Gardens, dying as a result of extensive peritoneal hæmorrhage associated with a diffuse endothelioma of the peritoneum, with extension over the urinary bladder, spleen, and liver, and secondary emboli of the same character in the lungs. There was also an abscess of the face which had passed by way of the spheno-maxillary fissure to the brain.

(*f*) A *Black-backed Jackal*, D.B. No. 476. Adenocarcinoma. Had been nearly six years in the Gardens and had shown no signs of any illness on the day before its death, and died after a short period of respiratory distress. There were growths in the thyroid gland, both lungs, the somatic pleura, and on the diaphragmatic surface, and in the bronchial glands.

(*g*) *Coucha Rat.* Hypernephroma. Both kidneys showed growth; there was a large hæmorrhage from that of the left side.

(*h*) *Rough-eyed Cayman*, D.B. No. 1049. The capsule of the liver was thickened, more over the right lobe than the left. The liver was occupied to the extent of nearly half its mass by a greyish-white deposit which infiltrated without any indications of a limiting border.

(*i*) *Indian Muntjac*, D.B. No. 1126. Six and a half years in the Gardens. Large growth of the anterior mediastinum.

(*j*) ***Viverrine Dasyure***, D.B. No. 1186. There was one large white tumour, the size of a cob-nut, in the under part of the left lobe of the liver, and several smaller masses (twelve in all) scattered generally throughout the organ. It had been killed by its companions, the throat being severely lacerated and the deep structures exposed.

4. *Special Cardio-vascular Conditions.*

(*a*) ***Scarlet Ibis***, D.B. No. 146. Death was due to Hæmopericardium, resulting from a tear at the root of the aorta. There was no atheroma.

(*b*) ****Falcated Teal***, D.B. No. 240. Aneurysm of the abdominal aorta.

(*c*) ****Pluto Cercopitheque***, D.B. No. 1103. Endocarditis and Renal infarcts.

(*d*) ***Lesueur's Water-lizard***, D.B. No. 1110. Filarial abscess of the Pericardium.

5. *Acute Hæmorrhagic Pancreatitis.*

(*a*) ***Reindeer.*** This animal was 8½ months old, having been born in the Gardens. The keeper stated that on the afternoon of the day preceding its death, he had found it lying on the ground, unable to rise. At the *post-mortem* the pancreas was practically converted into a hæmorrhagic mass, none of the gland being uninvolved. There were no worms found and no sign of any bruise or other injury.

(*b*) ***Himalayan Bear***, D.B. No. 541. Had been in the Gardens more than 14 years. It died suddenly, without having shown signs of any illness. The autopsy revealed a hæmorrhage occupying the whole of the head of the pancreas, and extending a short distance into the body. There were no helminthic parasites present. The liver was of a bright, boxwood colour; parts of it were taken and treated by the Levaditi method, but no Spirochætes or Leptospiræ were discovered.

6. *Duodenal Ulcer.*

Feline Genet, D.B. No. 491. Ulcer in the duodenum, opening up a blood-vessel. The duodenum and upper part of the intestine were filled with blood. No worms were present and the ulcer was single.

7. *Retropharyngeal Abscess.*

****Black Bear***, D.B. No. 587.

8. *Certain Blood Conditions.*

(*a*) ***Raccoon***, D.B. No. 108. In the Gardens nearly 3 years. Died with signs of jaundice and showed, *post-mortem*, cirrhosis of the liver and petechial hæmorrhages in the lungs. Blood-smears showed Piroplasma in large numbers. Such has not been previously described in this animal, and it may be a new species of this genus of protozoal parasites.

(*b*) ***King Penguin***, D.B. No. 730. Four months in the Gardens. Death was due to a combination of causes—Mycosis of the air-sacs and acute Enteritis, but the special point of interest to bring it under this head was the fact that the peripheral blood showed Proteosoma in enormous numbers. In some fields nearly every corpuscle was parasited, and many erythrocytes contained three and even four parasites. All stages could be seen, from small rings to actual division. This has not been described in the King Penguin. Dr. Wenyon states that it is certainly a new host. It may possibly be a new form of Plasmodium.

(c) *Javan Chevrotain*, D.B. No. 916. A recent arrival. The day prior to its death it had seemed perfectly well. At the autopsy there was hæmoglobinæmia and hæmoglobinuria. Blood-destruction was intense; several smears were made, but hardly a single intact corpuscle could be found. In the blood were Flagellates, diagnosed by Dr. Wenyon as *Selenomonas ruminantium*, in considerable numbers. These had probably nothing to do with causing the death, which was due to the hæmoglobinæmia and paroxysmal hæmoglobinuria, possibly the result of exposure, as the night of its death was a cold and frosty one.

(d) A *Senegal Chameleon*. Being in obvious respiratory distress, this was ordered to be killed. The blood was noticed at the necropsy to be very pale and thin, almost watery. Smears showed an enormous preponderance of leucocytes, the lymphocytic type. Over a count of many fields the white cells outnumbered the red, and in some there was a proportion of 5 white to 3 red—the picture of a Lymphocytic Leukæmia.

The following from the above list presented points of sufficient pathological interest to warrant a little further description :—

1. *Axis Deer* (*Axis axis*). This animal, a female, had been $2\frac{3}{4}$ years in the Gardens. She had shown no signs of illness prior to her death. Before the body was opened a tympanitic swelling, the size of a cocoanut, was noticed in the right lower quadrant of the abdomen. On reflection of the skin, bruising was seen in the pectoral muscles and in the abdominal muscles on the right side. As regards the viscera, there were adhesions of old standing at the apex of the right lung and many nodules, tuberculous in nature, with caseous contents scattered through both lungs, and enlargement with caseation of the bronchial glands. The sixth, seventh, and eighth ribs on the right side were fractured at about the middle of the shafts. The chief points of interest were found in the abdomen. There was a hernial opening at the outer edge of the right rectus, some three inches in diameter, through which several feet of the small intestine had passed; the coils were purple in colour, but still retained some lustre. The whole was included in a false membrane consisting of thinned omentum and lying beneath the subcutaneous fascia. Inside the abdomen several feet of the intestine were in a similar condition of commencing strangulation due to dragging on and compression of the mesenteric vessels. The peritoneum was beginning to dull. There was a small hydatid lying on the surface of the stomach.

The probable explanation of matters is that the fracture of the ribs and bruising of muscles were injuries inflicted by her male companion, and through a weakened spot in the abdominal wall the hernia had taken place and the bowel had become strangulated. There was also tuberculosis of both lungs.

2. *Spotted Hyæna* (*Hyæna crocuta*). Two years in the Gardens; died after a brief illness, and on arrival at the Prosectorium a large fluctuating swelling was noticed in the abdomen. When the body was opened, the peritoneal cavity was found to be full

of thin, flaky, turbid, purulent fluid. The parietal peritoneum was gangrenous, and, in a mass of clot and broken-down necrotic matter, in the great omentum was a fragment of sharp, ragged bone, two inches in its longest diameter and one-half to one-third of an inch in its narrowest. All the viscera were bathed in purulent lymph, the liver being covered with it, as was also the spleen; the pancreas was embedded in coagulum and lymph. In the stomach there were signs of old ulcers which had completely cicatrized, and careful search of the stomach and intestine failed to reveal any perforation. Towards the pylorus there was a site where there were indications of more recent healing.

A suggested interpretation is that perforation had taken place at this spot into the lesser sac of the peritoneum; that an abscess had formed in this lesser sac, which had subsequently ruptured and produced the condition of general peritonitis revealed at the autopsy.

3. A *Blue Wildebeest* (Brindled Gnu) (*Gorgon taurinus*). Came to the Gardens $2\frac{1}{4}$ years prior to its death. On arrival, enlargement of the abdomen was noticed, and was thought to be due to what is euphemistically termed an "interesting condition." The enlargement became progressively and steadily greater At death a very large accumulation of ascitic fluid was present, $61\frac{1}{2}$ litres (about 106 pints) were actually measured, while some was lost in the tapping and some remained behind and could not be measured with accuracy. The condition was found to be due to an extensive growth of the great omentum which formed a sheet of more than an inch in thickness, whitish with small hæmorrhagic areas, granular or slightly nodular on the surface. Secondary deposits were present on the under-surface of the diaphragm and attached to the liver and spleen, but not infiltrating either viscus. Microscopical examination revealed the growth to be an endothelioma.

4. An *Indian Rhinoceros* (*Rhinoceros unicornis*) had been in the Gardens 4 years. For some three weeks preceding its death its appetite had failed, but it had not shown any other signs of illness until the morning of April 28th, 1926, when at 6 A.M. it appeared to be in distress and died shortly afterwards.

At the autopsy there were several findings of importance, but the chief interest lay in a mass of deposits of new growth—some hundreds in all—covering practically the whole of the anterior surface of the heart, nodular in appearance, some of the nodules showing hæmorrhages. On the posterior also there was a large number, but fewer than on the anterior. Growths were present within the walls of the ventricles and auricles, varying greatly in size, the largest being about that of a golf-ball. There was a nodule as large as a cherry in the left lung, and one the size of a Tangerine orange in the right.

Microscopical examination showed the tumours to be of a sarcomatous nature with a relatively large number of giant-cells. The primary site cannot be stated; there was no obvious bone-growth.

In addition to the above, the intestinal mucous membrane was acutely inflamed, in parts hæmorrhagic, and there was a generalized infection with *B. welchii* (*B. ærogenes capsulatus*).

5. An *Otter* (*Lutra lutra*). Died suddenly, after being in the Gardens for a little over a year and showing nothing except a slight swelling towards the right side of the midline of the neck. On making the *post-mortem* examination, I found the right side of the thyroid gland enlarged and occupied by a growth in which there were a few foci where the tissue was breaking down. Extending from the lower pole of this swelling, in an outward direction into the tissues of the neck and infiltrating the muscle-planes, and internally pressing upon the trachea, was an abscess containing fully half a pint of creamy pus. In the middle and inner parts of the thyroid swelling was another, paler and appearing distinct from the former, about as large as a small walnut. On the left side the thyroid itself appeared normal, but partly enclosed in it was a greyish tumour exactly simulating, except in being smaller, the internal part of the tumour on the right side.

Pieces were taken for section: (*a*) from the outer part of the tumour on the right side, where extension was occurring into the muscles of the neck; (*b*) from the "thyroid" tumour; (*c*) from the "inner" tumour on the right side; (*d*) from the tumour on the left.

In none of the sections examined from the right side could any thyroid tissue be made out; the structure was that of a round-cell sarcoma, infiltrating the muscles, and it seemed to have entirely destroyed this lobe of the thyroid. The internal part—the paler tumour—showed a totally different structure, namely that of a carcinoma of the parathyroid. The growth on the left side showed a condition exactly like the last. This combination is exceedingly rare; I can find no record of such in human pathology, but a brief mention of three cases in animal pathology, one in a horse and two in dogs.

6. A *Falcated Teal* (*Nettium falcata*). Suddenly died in the midst of apparently perfect health. At the *post-mortem* the abdomen was found to be full of blood. Examination showed this to have arisen from bursting of an aneurysm of the abdominal aorta; the swelling was nearly as large as a cherry. Half an inch above this there was another aneurysm, the size of a cherry-stone. No parasites were discovered, nor was there seen any atheroma or calcification, either on naked-eye, or even microscopical, examination. This bird had been in the Gardens nearly 14 years.

7. A female *Pluto Cercopitheque* (*Cercopithecus leucampyx*). This animal had been here for 16 years all but ten days, and had exhibited no symptoms of disease prior to its sudden death. The chief interest centered in the cardiac condition. There were patches of fibrous myocarditis in the wall of both ventricles. The septal cusp of the mitral valve was thickened, as was also the mural cusp, but on the latter there was a large, granular, cauliflower-like vegetation. On the contiguous mural endocardium

there was a vegetation of considerable size, as large as a small pea, and the cavity of the left ventricle contained *ante-mortem* clot. The aortic, pulmonary, and tricuspid valves were unaffected. Each kidney showed an extensive, puckered, and depressed cicatrix, probably the residue of old infarcts.

8. A *Black Bear* (*Ursus americanus*), female, 10½ years in the Gardens; died after a brief period of acute respiratory distress. At the autopsy the signs of acute asphyxia were present, congestion and petechial hæmorrages in the trachea, and similar petechiæ on the surface of the lungs, the bronchi containing frothy material. The blood-vessels were engorged with semi-clotted blood of the colour and consistency of molasses. There were small petechiæ and hæmorrhagic extravasations on the pericardial surface. There was no laryngeal obstruction. The condition had arisen from a retro-pharyngeal abscess, 10 × 4 × 4 cm., opening into the laryngeal pharynx by an aperture 1 cm. in diameter. There was a well-marked pyogenic membrane lining the wall of the abscess-cavity.

The course of events was as follows:—The retropharyngeal abscess had been caused by a small sharp fragment of bone (which was found). This abscess had extended upwards and laterally behind the pharynx and in the prevertebral space. The contents of the abscess had been almost completely discharged into the respiratory tract, and had been aspirated into the lungs. Hence the attack associated with the respiratory distress noted just prior to the death of the animal.

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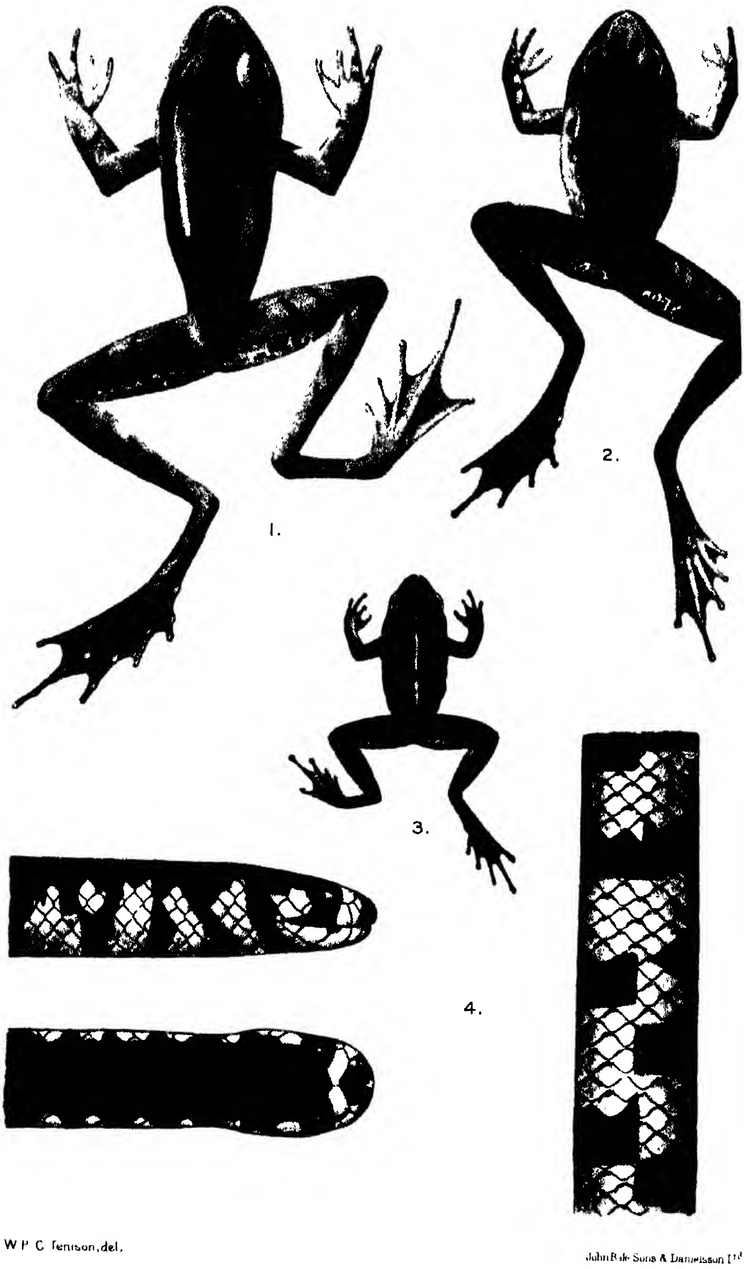
HERPETOLOGY OF THE INDO-AUSTRALIAN REGION.



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HERPETOLOGY OF THE INDO-AUSTRALIAN REGION.

13. Contributions to the Herpetology of the Indo-Australian Region. By Malcolm Smith, M.R.C.S., L.R.C.P., F.Z.S.

[Received December 4, 1926: Read February 22, 1927.]

(Plates I., II.*; Text-figures 1–4.)

Early in 1924, in company with my wife, I visited the Malay Archipelago, our chief object being to collect herpetological and botanical (ferns) material. In the course of travelling from one place to another, we visited nearly all the small islands of note east of Java; but as our stay at each one was limited to a day or less, not much collecting was done upon them. The bulk of the material included in this article was obtained in three well-separated localities: namely, in the mountains of East Java, on Mt. Bonthain in South Celebes, and in South (Dutch) Timor.

On Mt. Bonthain we remained a month (Jan. 15th to Feb. 15th), headquarters being at Djikoro, a small farm owned by Mr. Lienhardt on the south-western slopes of the mountain, at an altitude of about 1200 metres. Djikoro is not marked on the map, but lies at a slightly higher altitude and about five kilometres distant from Malakadji, where there is a Government Rest-house and a large native market. Using Djikoro as a base, excursions were made upon the mountain in various directions. The country in the immediate vicinity is open, and interspersed with numerous small well-wooded and well-watered ravines. Rain fell almost daily during our stay there

Considerable collections of reptiles and batrachians have been made on Mt. Bonthain in the past, both by the brothers Sarasin and by Everett; their labours, however, have not exhausted the mountain, as the following results will show.

The ascent of Mount Bonthain (3300 metres), if undertaken during the dry season, is not difficult, but at the time I climbed it, owing to rain and fog, it was distinctly unpleasant. At an altitude of about 1800 metres I entered a belt of dense evergreen jungle which extended upwards for nearly 1000 metres. Above this level the trees were few and dwarfed, their place being taken by huge moss and lichen-covered boulders and thick grass about two feet high. From the branches of all the trees at the higher levels, long festoons of pale grey or white lichens were hanging, giving the scene a most wintry aspect.

On Timor we spent two months (Feb. 26th to April 29th), staying first at Kupang on the coast and afterwards travelling into the interior. Our highest altitude was reached at Soë (800 metres). From a herpetological point of view, Timor is one

* For explanation of the Plates see p. 225.

of the most disappointing places that one can visit. Considering its size and its position in the Tropics, there is probably no other island so barren in reptilian and batrachian life. Its geological structure and its comparatively recent origin (speaking from a geological point of view) no doubt account for this. The investigations of Mollengraaf, Wanner and party show that it appeared some time in the Pleistocene era, and was formed by an upheaval of the ocean-bed, the thick strata of coral limestone which at that time formed the sea-floor being carried with it *. Thus it is that even the tops of the mountains are covered with coral deposit, and soil, as the term is used in the ordinary sense, is scanty or absent. In the vicinity of Soë there are large areas of limestone outcrop where nothing can grow except short grass and a few hardy trees. The scarcity of batrachian life is also accounted for by the lack of suitable habitats. All springs of water before they reach the surface must pass through the limestone strata already mentioned, and being in consequence heavily impregnated with lime, are inimical to most forms of aquatic life. The almost complete absence of animal life in and about the small streams is in striking contrast to what obtains in other tropical Asiatic countries. The few species of frogs that exist on the island do so in the ponds formed by rain-water, and no doubt æstivate if these should dry up, as the whole country does between May and October, when no rain falls †.

The herpetological fauna of Timor is mainly of Asiatic origin. All the widely-distributed forms are Asiatic, and the few which are peculiar to Timor or the Timor Archipelago (the islands lying between Timor and Flores) have no doubt been derived from Asiatic stock. As an instance of the preponderance of Asiatic forms, I may mention that during my stay in Kupang every species of reptile and batrachian I obtained could, with one exception, have been caught in my garden in Bangkok 2300 miles away in a direct line, and separated from it by the whole of the Malay Archipelago. Five species appear to have reached the island either from New Guinea or Australia; these are *Hyla infrafrenata*, *Lygosoma fuscum*, *Python amethystinus*, *Typhlops polygrammicus*, and *Varanus timorensis*.

The following table will show the distribution of the species:—

	Batrachians.	Lizards.	Snakes.
Total number	5	15	12
Widely-distributed species	2	9	6
Peculiar to Timor or the Timor Archipelago	2	5	3
Common to Timor and New Guinea or Australia	1	1	3

* See Mollengraaf, in Arch. Néerland. Sc. Nat., Haarlem, 1915, vol. ii., and 12th Congr. Internat. Geology, Toronto, 1913.

† The above remarks apply to the south of the island. I did not visit the north, but from all accounts the conditions there are the same.

A number of observations were made upon habits and life-histories, and will be found recorded in their turn. Of special interest is the spawning habit of *Rana palavanensis*, which is unusual and has not, so far as I am aware, been recorded of any other species of *Rana*. Another point is in connection with *Rana microtympanum*, one of a group of Asiatic frogs characterized by enlargement of the head of the adult male and the development of tooth-like processes in the lower jaw. The function of these processes is not yet known, but it has been suggested that they are used for fighting during the breeding-season. I do not think they are intended for defence, as the species provided with them make no attempt to bite when captured.

The processes are not always exposed, as is usually stated. It would appear that when not in use the mucous membrane of the mouth grows up and covers them completely, and they then appear as more or less bulbous projections. As soon as pressure is put upon them they break through the membrane, and with their sharp points can be a formidable weapon.

The spinous pollex of *Rana holstii* and of *Phrynella pollicaris* is exposed in exactly the same way during the breeding-season and covered with membrane at other times.

The following forms are described as new; the types have been presented to the British Museum of Natural History:—

BATRACHIANS.

Oœidozyga semipalmata, sp. n.
Oœidozyga celebensis, sp. n.
Rana timorensis, sp. n.
Rana arathooni, sp. n.

LIZARDS.

Lygosoma (Omolepida) antoniorum, sp. n.
Lygosoma (Leiolopisma) spinauris, sp. n.

SNAKES.

Cylindrophis celebensis, sp. n.
Dendrophis pictus timorensis, subsp. n.
Calamaria apræocularis, sp. n.

The range of the following species is extended:—

BATRACHIANS.

Oœidozyga lævis (Günther). Bima, Sumbawa.
Rana doriæ Boulenger. Songgoriti, Java.
Rana chalconota (Schlegel). Maros, S. Celebes.
Bufo biporcatus Gravenhorst. Maros, S. Celebes.

LIZARDS.

Gymnodactylus jellesmiæ Boulenger. Lowah, S. Celebes.
Gymnodactylus (?) *marmoratus* (Kuhl). Djamplong, S. Timor
Hemidactylus brookii Gray. Kupang, S. Timor.
Dibamus novæ-guineæ D. & B. Endeh, Flores.

Snakes.

Dendrophis pictus (Gmelin). Lowah, S. Celebes.
Elaphe erythrura (D. & B.). Lowah, S. Celebes.
Psammodynastes pulverulentus (Boie). Lowah, S. Celebes.

Three species are suppressed:—

Gehyra beebei Annandale.
Mabuya rudis Boulenger.
Draco walkeri Boulenger.

No Agamid Lizard, with the exception of one species of *Draco* and one of *Varanus*, has been recorded from Timor. It is of interest to mention, therefore, that on the road from Djamplong to Soë a large lizard, apparently of the genus *Physignathus*, was seen.

The following localities are mentioned as having been collected in:—

1. *Songgoriti.* In East Java, altitude 1200 metres. Well populated and cultivated, except in the ravines.
2. *Djikoro.* On the southern slopes of Mt. Bonthain, South Celebes, altitude 1200 metres. Open country interspersed with well-wooded valleys and numerous streams.
3. *Lowah.* About 20 kilometres S.S E. from Djikoro, altitude 650 metres. Wooded hilly country with numerous streams interspersed with cultivation.
4. *Peak of Bonthain.* Dense evergreen-jungle, growing below the peaks of the mountain from 2000 to 2700 metres altitude.
5. *Maros.* Low limestone hills (about 500 metres altitude) of peculiar formation, 30 kilometres north of Macassar. An excellent account of these remarkable hills has been given by Wallace in his 'Malay Archipelago.'
6. *Kupang.* The seaport of southern Timor. Undulating country with deciduous jungle, which dries up completely between May and October.
7. *Djamplong.* 55 kilometres by road from Kupang. Undulating country (100 to 200 metres altitude), well wooded and with numerous small streams.
8. *Lélogama.* Altitude 750 metres. Steep hills everywhere, well wooded and with innumerable streams.
9. *Soë.* Altitude 800 metres. Much of the country around consists of open hillsides covered with short grass and black limestone outcrops. The ravines are well wooded, but there is little real soil.

BATRACHIANS.

Genus Oœidozyga.

Oœidozyga Kuhl & Van Hasselt, Isis, 1822, p. 475.

Occidozyga "Kuhl," in Bull. Sc. Nat. Géologie, Paris, ii. 1824, p. 83 (French translation).

Oxydozyga "Kuhl" in Tschudi, Mém. Soc. Sc. Nat. Neuchâtel, ii. 1838, p. 85; Stejneger, Proc. U.S. Nat. Mus. lxvi. 1925, p. 33.
Oxyglossus Tschudi, Mém. Soc. Sc. Neuchâtel, ii. 1838. p. 85.

Dr. Stejneger has recently shown that the well-known name of *Oxyglossus* Tschudi is preoccupied for a genus of birds (Swainson, 1828), and that it must be replaced by *Oxydozyga* Tschudi. The fact is immaterial, however, as *Oxydozyga*, or rather *Oœidozyga*, antedates *Oxyglossus* Swainson by some six years, the name being first mentioned by Kuhl and Van Hasselt in 1822. It was accompanied by a short description, and an indication (ovalkröte) of the derivation of the word, which places its spelling beyond doubt *.

1. Oœidozyga semipalmata, sp. n. (Pl. II. fig. 3.)

Description of the Type.—Adult, author's number 8728. Collected at Lowah, near Mt. Bonthain.

Tongue rounded behind as in *O. lævis*, but larger; eyes prominent; head a little broader than long; snout rounded, short, as long as the upper eyelid; no canthus rostralis; loreal region oblique; nostrils midway between the eyes and the tip of the snout, the distance between the nostrils nearly twice the interorbital space, which is narrower than the upper eyelid; tympanum hidden. Fingers with very small discs, the first finger slightly shorter than the second, which is about as long as the fourth; toes with larger discs than the fingers, the third toe distinctly longer than the fifth, two-thirds webbed, the membrane extending up the sides of the digits as far as the discs; a feeble fringe along the outer side of the fifth toe; subarticular tubercles small; an oval inner metatarsal tubercle, one-third the length of the inner toe; no outer tubercle; a feeble tarsal fold; the heel reaches the anterior border of the eye; the tibia is not quite half the length of the head and body. Skin smooth.

Colour.—Olive-brownish above, with indistinct darker markings; limbs paler, with dark cross-bars; below greyish-white, the throat and limbs speckled with brown.

Dimensions.—From snout to vent 30; breadth of head 10·5; hind-limb 43; foot 14 mm.

Variation.—In some examples the toes are only half-webbed; the heel may reach nearly to the tip of the snout; the skin of the upper parts, especially in young examples, may have small, scattered, rounded warts. A narrow yellow or orange vertebral stripe is sometimes present; in young specimens the dark markings are more pronounced and the throat may be almost black, with small white dots. Four specimens have a broad dark band down the back, occupying nearly the whole width, with the sides of the body yellow.

O. semipalmata differs from the other members of the genus in having distinct discs to the fingers and a shorter web to the

* ὠοειδος=egg-shaped, and (?) ζυγόν=an arch or yoke.

toes. It was common in the mountain-streams at Lowah, and I obtained it also at Djikoro and near the falls of Maros, north of Macassar. It seemed to prefer situations where the rocks were steepest, and to avoid capture would leap down the most precipitous places, apparently without injury.

The tadpoles have the same pointed snout and distinctive mouth which characterize the other larvæ of this genus.

Description of the Tadpole.—Length of head and body one and two-thirds times its breadth; nostrils much nearer the eyes than the tip of the snout; eyes superolateral, the interocular width a little less than that between the nostrils; spiraculum sinistral, directed backwards and upwards, midway between the eye and the vent, which is median. Tail long and narrow, the tip acutely pointed; crests low, subequal, both of them commencing well behind the root of the tail. Mouth with an inverted horseshoe-shaped lower, and a very small upper, lip, the two making together an almost circular orifice; no papillæ or teeth; beak black.

Colour.—Olivaceous above, paler below.

Dimensions of a specimen with the hind-limbs well developed.—Length of head and body 12; breadth of body 7·5; length of tail 27; greatest height of tail 4 mm.

2. Oœidozyga celebensis, sp. n.

Description of the Type.—Adult female, author's number 8675. Collected at Djikoro, Mt. Bonthain.

Tongue oval, rounded behind; eyes prominent; head a little broader than long; snout rounded, as long as the upper eyelid; no canthus rostralis; loreal region oblique; nostrils midway between the eyes and the tip of the snout; distance between the nostrils twice the interorbital space, which is much narrower than the upper eyelid; tympanum hidden. Tips of the fingers bluntly pointed, the third a little longer than the second and fourth; toes with small discs, fully webbed: subarticular tubercles small: inner metatarsal tubercle oval, one-third the length of the inner toe, no outer tubercle; the heel reaches to midway between the shoulder and the eye; the tibia is two and a half times in the length of head and body. Skin smooth, with a few scattered, rounded warts above; a fold from the eye to the shoulder.

Colour.—Olive above with indistinct darker markings, below yellowish.

Dimensions.—From snout to vent 33; breadth of head 12; hind-leg 43; foot 14 mm.

Variation.—The outer three fingers may be of equal length; the heel may reach as far as the eye; the throat is sometimes spotted. Males are smaller than females; the largest male is 27 mm. from snout to vent.

O. celebensis is very closely allied to *O. lævis* from the Malay

Archipelago and Indo-Chinese region, in which species the third finger is very distinctly longer than the second and fourth and the inner metatarsal tubercle is larger, about half the length of the inner toe. The differences are slight, and my chief reason in separating it is that the call of this frog is entirely different to that of *O. lævis*, as I know it in Siam.

O. celebensis was common in open marshy ground both at Djikoro and at Lowah, and I obtained many specimens.

To this species I refer the specimens in the British Museum collected in South Celebes by Everett, but not the specimens from northern or Central Celebes obtained by the Drs. Sarasin.

The tadpole (from southern Celebes) was originally described by Boulenger under the name of *O. lævis*. It does not differ from that which has now been assigned to the true *O. lævis*.

3. RANA CANCRIVORA and its allies.

Rana cancrivora, Boulenger, Rec. Ind. Mus., xx. 1920, p. 23; Van Kampen, Amphib. Indo-Austral. Archipel, p. 170 (1923).

Rana verruculosa, Boulenger, Rec. Ind. Mus., xx. 1920, p. 16; Van Kampen, Amphib. Indo-Austral. Archipel., p. 172 (1923).

Rana moodiei, and *R. vittigera*, Taylor, Philipp. Amphib., pp. 234 & 236 (1920).

Rana cancrivora has been separated from *R. verruculosa* in having a dermal fringe along the outer border of the fifth toe instead of a ridge, and in having longitudinal folds upon the skin of the back instead of elongated warts. The former inhabits the Malay Archipelago and S.E. Asia, the latter the islands of the Timor Archipelago. *R. vittigera*, which is found in the Philippine Islands, has been regarded by Boulenger as identical with *R. cancrivora*, but has been revived by Taylor as a distinct species (1920). He has also described another frog which he has called *R. moodiei*, specimens of which he has kindly sent me for examination. As I find myself unable to distinguish this frog from *R. cancrivora*, the present remarks concern only the three forms—*cancrivora*, *verruculosa*, and *vittigera*. The relationship of these three is undoubtedly very close, and their precise status in classification still leaves room for discussion.

With the object of studying these frogs more closely, I collected them extensively while in Celebes and Timor, and also observed them in life as far as I was able. This collection, supplementing the material already in the British Museum, another collection of my own from Siam, and a series of specimens kindly sent me by Mr. E. H. Taylor from the Philippine Islands, covers nearly the whole region over which these frogs are to be found.

Their habits, as I have observed them in Siam, Celebes and Timor, are the same, the breeding-call of the males is identical, and their tadpoles are indistinguishable from one another. They are never found many miles from the sea and—*R. cancrivora* at any rate—can enter salt water with impunity. Annandale states

that he has seen one jump into the sea and swim ashore apparently without suffering (Rec. Ind. Mus., xx. p. 24), and I have found them at most of the river-mouths in peninsular Siam, where the water is more or less brackish. The tadpoles discovered by Mr. A. S. Pearce in almost pure salt water probably belonged to this species (Philipp. Journ. Sc., vi. p. 219). On the other hand, I have met *R. cancrivora* in rice-fields on Mt. Bonthain at a height of 1000 metres.

Of the distinguishing characters mentioned, the glandular folds of the back cannot be relied upon when considering the species over their whole range. All specimens of *R. cancrivora* from Borneo, Sumatra, Java, and Celebes have longitudinal folds, and most specimens of *R. verruculosa* have elongated warts, but specimens of *R. cancrivora* from Bangkok show extremes of either, so that the test when applied to the Siamese form breaks down entirely. In the Philippine Islands the folds are broken up.

The dermal fringe along the outer border of the fifth toe is more reliable, and although the difference between a definite flap of skin and a mere ridge may seem slight, there is seldom any difficulty in deciding which to call it.

Taylor maintains that the frog with the digital fringe (his *R. moodiei*) is distinct from the one that has none, and that the two live and breed side by side in the same ponds. He gives other characters by which to distinguish them, but they are less easily seized upon and of doubtful value. His contention, however, that there are two species, based upon the presence or absence of a dermal fringe, is confirmed by the series of specimens from the Philippine Islands contained in the British Museum. A similar state of affairs appears to exist on the island of Sumba, where I obtained frogs that I refer respectively to *R. cancrivora* and *R. verruculosa*.

R. cancrivora, with its digital fringe, therefore, can be separated from *R. vittigera* and *R. verruculosa*, which have only a ridge of skin, and in the absence of intermediate forms should be maintained as distinct. Whether *R. vittigera* and *R. verruculosa* are separable is not so easily decided. With a slight difference in the length of the hind-limb and a different geographical distribution they are probably distinct species.

The following synopsis is drawn up from the material at my disposal:—

Rana cancrivora.

1. A well-developed membranous fringe along the outer border of the fifth toe; back with longitudinal glandular folds; a light vertebral line present or absent. Java (*forma typica*); Sumatra; Borneo; Celebes; Lombok; Sumbawa. (25 specimens examined.)

2. A well-developed fringe on the fifth toe; back with longitudinal folds or elongated warts; light vertebral line absent.

Southern and Central Siam; Indo-China*; Philippine Is. (*R. moodiei*). (40 specimens examined.)

Rana verruculosa.

3. Digital fringe reduced to a mere ridge, sometimes absent; back usually with elongated warts; heel reaching to anterior border of eye or not so far: light vertebral line absent.

Sumbawa; Sumba; Timor; Wetar (type-locality); Allor I.; Dammer I. (23 specimens examined.)

Rana vittigera.

4. Digital fringe as in 3; back with longitudinal folds more or less broken up; heel reaching to beyond the eye; light vertebral line present or absent.

Philippine Islands. (15 specimens examined.)

4. Rana arathooni, sp. n. (Pl. II. fig. 2.)

Description of the Type.—Adult male, author's number 8627. Collected at Djikoro, Mt. Bonthain, S. Celebes, in Feb. 1925.

Vomerine teeth in oblique series commencing between the choanæ and extending posteriorly beyond them, their distance from the choanæ equal to their distance from each other; lower jaw with small tooth-like processes; no papilla on the tongue. Head not large, distinctly broader than long; snout subacuminate, scarcely projecting beyond the lower jaw, a little longer than the upper eyelid; canthus rostralis obtuse; loreal region oblique, feebly concave; nostril equidistant from the eye and the tip of the snout; interorbital space as broad as the upper eyelid; tympanum quite distinct, three-fifths the diameter of the eye.

Fingers with feebly-swollen tips; toes with small discs, without crescentic groove between the upper and lower surfaces; first finger as long as the second, shorter than the fourth; toes nearly entirely webbed, two and a half phalanges of the fourth toe free; third toe scarcely longer than the fifth. An oval inner metatarsal tubercle, half the length of the inner toe; no outer tubercle; a fringe of membrane along the outer side of the fifth toe; outer metatarsals separated nearly to the base; the heel reaches to beyond the tip of the snout; the heels strongly overlap when the limbs are folded at right angles to the body; tibia $1\frac{3}{4}$ times in length from snout to vent, a little longer than the foot. Skin of the back nearly smooth; an indistinct glandular dorsolateral fold from the upper eyelid to about the middle of the back; a curved fold from the eye to the shoulder; below quite smooth.

Two small internal vocal sacs at the angles of the jaw; no gland on the fore-limb. Omosternum with forked base; nasal bones moderate in size, separated from one another on the mid-line.

* Included in the range on the evidence of its breeding-call, which I heard one night at Cap St. Jacques. The cry—a loud bleat—is so unmistakable, that I feel sure it could have come from no other species.

Colour.—Blackish-grey above with indistinct lighter and darker markings; limbs with black cross-bars; below yellowish, throat speckled with grey.

Variation.—The first finger may be a little longer than the second; the tympanum in some examples is only half the diameter of the eye; the interorbital space may be a little narrower than the upper eyelid.

Five specimens examined (Nos. 8584–5, 8626–7, 8645), all males. They were caught after dark, their call—a shrill half-whistling note, much like the noise made by certain species of cricket—betraying their whereabouts among the dense herbage in which they lived.

Dimensions of the Type.—Length of head and body 42; breadth of head 18; eye 4·5; hind-limb 77; foot 23 mm.

R. doriæ, to which this new species is most nearly related, differs in having no tooth-like processes in the lower jaw and, in the male, no vocal sacs. *R. palavanensis* differs in the longer snout, more prominent eye, shorter web to the toes and much smaller size; *R. macrodisca* has a larger head, longer legs, a shorter web to the toes, and, in the male, no vocal sacs.

I have named the frog after Mr. L. S. Arathoon, British Consul at Macassar, to whom I was indebted for much assistance in collecting during my stay on the island.

5. Rana doriæ.

Boulenger, Rec. Ind. Mus., xx. 1920, p. 49.

5 examples. Songgoriti, Java.

They were found in a deep ravine, where they could be heard calling in the evening high up on the banks away from water.

The specimens agree well with the types from Tenasserim contained in the British Museum, except that they have the snout a little more pointed and the vomerine teeth placed a little more obliquely.

The species has not yet been recorded from the Malay Archipelago.

6. Rana palavanensis.

Van Kampen, Amphib. Indo-Austral. Archipel., p. 182.

This small frog was abundant along the streams and in marshy spots at Djikoro. Its short call, something like the noise produced by a rattle, was heard at all hours of the day or night. All my specimens, as well as those in the British Museum collected by Everett in South Celebes, have the back marked with numerous longitudinal glandular folds, whereas the types of *R. palavanensis* and specimens from Borneo have the back smooth except for the dorsolateral folds.

On several occasions I found the spawn of this frog. It was not deposited in the water, but the eggs (35 to 45 in number) were spread out upon a rock or on the upper surface of a broad

leaf in a shady spot overhanging the water, and without covering or protection of any kind. The larvæ as they develop wriggle out of their envelope and drop into the water below, where they continue their metamorphosis in the usual manner.

Description of Tadpole.—Head and body depressed, its length one and a third times its breadth; nostrils midway between the eyes and the end of the snout; eyes superolateral, the distance between them about equal to that between the nostrils; spiraculum sinistral, directed upwards and backwards, much nearer the eye

Text-figure 1.

Mouth of tadpole of *Rana palavanensis*.

than the vent, which is dextral; tail four times as long as high, the tip pointed; crests low, subequal, the upper commencing behind the root of the tail; mouth subterminal, small; a fringe of short papillæ at the sides and below; teeth feebly developed, upper lip with two rows, the uppermost long and uninterrupted, the second broadly interrupted; lower lip with three rows, the uppermost slightly interrupted, the second uninterrupted and nearly as long as the first, the lowest very short; mandibles edged with black.

Colour.—Olivaceous, with dark mottlings most conspicuous on the tail.

Dimensions of a specimen with the hind-limbs well developed.—Length of head and body 14; breadth of body 8·5; length of tail 23; height of tail 6 mm.

7. Rana microtympanum. (Pl. I. fig. 1.)

Rana microtympanum, Van Kampen, Weber's Zool. Ergebn. Leiden, iv. 1907, p. 386; Bouleng. Rec. Ind. Mus., xx. 1920, p. 48.

Rana modesta (part.), Van Kampen, Amphib. Indo-Austral. Archipel., p. 176 (1923).

22 examples. Djikoro, Mt. Bonthain.

Rana microtympanum was originally described from juvenile examples, and has since (1923) been regarded by its author as identical with *R. modesta*. With the large series now available from the type-locality for examination, however, I believe Professor Van Kampen's first opinion to have been the correct one.

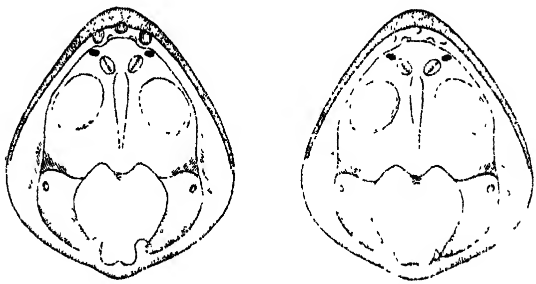
The two can be separated on the following characters :—

R. microtympanum.	*R. modesta.*
First finger usually shorter than second.	First finger extending distinctly beyond second.
Tympanum indistinct or hidden in the adult.	Tympanum distinct in the adult.
Digital discs of toes large.	Digital discs of toes small.
Prevailing colour above blackish; no light vertebral stripe.	Prevailing colour above olivaceous; a light vertebral stripe present or absent.

The following description of *R. microtympanum* is drawn up from my series :—

Vomerine teeth in oblique series commencing between the choanæ and extending posteriorly beyond them, their distance

Text-figure 2



Mouth of *Rana microtympanum* showing tooth-like processes covered and exposed.

from each other about equal to their distance from the choanæ. Lower jaw with bony prominences in front, strongly developed in adult males ($2\frac{1}{2}$ mm. long) and fitting into deep pits in the upper jaw. Head larger in the male than in the female, broader than long, much depressed; snout obtusely pointed, feebly projecting beyond the lower jaw, as long as or a little longer than the upper eyelid; canthus rostralis distinct; loreal region oblique, concave; nostril midway between the eye and the tip of the snout; interorbital space as broad as or narrower than the upper eyelid in females and young, broader than the upper eyelid in adult males; tympanum indistinct, one-third to one-half the diameter of the eye, often entirely hidden in adult males. Tips of fingers swollen or with very small discs, the first not extending as far forwards as the second (as far forwards in four examples), which is shorter than the fourth; toes with well-developed discs, the third toe longer than the fifth, entirely webbed: subarticular tubercles well developed; an oval inner metatarsal tubercle, half or more than half the length of the inner toe; no outer tubercle; a strong fringe along the outer side of the fifth toe; outer metatarsals

separated nearly to the base; the heel reaches the anterior border of the eye in the adult, a little farther in the young; the heels meet when the limbs are folded at right angles to the body; tibia twice or less than twice in length from snout to vent, as long as or shorter than the foot.

Skin of the back with short folds or elongated warts; a strong, curved fold from the eye to the tympanum.

Colour.—Blackish or dark greyish with lighter markings; limbs with scarcely distinct dark cross-bars; below whitish, uniform or thickly speckled with dark grey.

Male with internal vocal sacs. Omosternum with forked base; nasal bones in contact with one another.

Dimensions.—From snout to vent 71; length of head 27; breadth of head 31; hind-limb 110; foot 37 mm.

Range.—Southern Celebes.

This frog was fairly common at Djikoro, but strictly nocturnal in its habits. I never saw any during the day, but could get plenty of them after dark when they were hopping about on the rocks and stones of a small stream near my camp.

Van Kampen (1923) has placed *R. magna* Stejneger (type-locality Mindanao, Philippine Is.) in the synonymy of *R. modesta* Boulenger (type-locality N. Celebes). He may be right in doing so, but it would probably be more correct to describe *R. magna* as a race of *R. modesta* characterized by its larger size and greater cranial development.

Rana modesta does not exceed 72 mm. in length from snout to vent (♂); *R. magna* reaches 113 mm. (♂).

R. modesta appears restricted to the Celebes and perhaps some of the small islands south of it; *R. magna* is known from the Philippine Archipelago.

R. microtympanum is indistinguishable from *R. kuhli* except for the presence of internal vocal sacs in the male, and *R. modesa* is only distinguishable from *R. macrodon* by the same character.

R. kuhli and *R. macrodon* I believe to be true Malayan Frogs, being confined to Sumatra, Java and Borneo in the Malay Archipelago. *R. microtympanum*, *R. modesta*, and *R. m. magna* inhabit the Celebes and Philippine Islands. All the specimens recorded as *R. macrodon* from the Philippine Islands that I have had the opportunity of examining are, I believe, *R. m. magna*. All are females and consequently have no vocal sacs. There is a single example of *R. kuhli* in the British Museum recorded from the Celebes, and its origin may be doubted. It was presented in 1858 by Sir A. Smith, and was part of a collection which included frogs from all over the world.

8. Rana timorensis, sp. n. (Pl. II. fig. 1.)

Description of the Type.—Adult male, author's number 8862. Collected at Djamplong, S. Timor.

Vomerine teeth in two small oblique series between the choanæ, their distance from each other equal to their distance from the

choanæ. Head not enlarged, as broad as long, somewhat depressed; snout subacuminate, feebly projecting beyond the lower jaw, as long as the upper eyelid; distance between the nostrils greater than the interorbital breadth, which is broader than the upper eyelid; canthus rostralis distinct; loreal region oblique, slightly concave; nostril midway between the eye and the tip of the snout; tympanum quite distinct. three-quarters the diameter of the eye. Tips of fingers swollen; first finger longer than the second, which is a little shorter than the fourth; tips of toes with small but quite distinct discs; no crescentic groove separating the upper and lower surfaces; third and fifth toes equal; toes nearly fully webbed, two phalanges of the fourth and two phalanges on the inner sides of the second and third being free; subarticular tubercles well developed; an oval inner metatarsal tubercle one-third the length of the inner toe; a small rounded outer tubercle; outer metatarsals separated nearly to the base. The heels reach the tip of the snout and strongly overlap one another when the limbs are folded at right angles to the body; tibia three-fifths the length of the head and body, as long as the foot. Skin of the back smooth; a fairly well-defined dorsolateral fold reaching from the upper eyelid to the groin; no fold from the eye to the shoulder.

Colour.—Grey above with lighter and darker mottlings; a dark streak below the canthus rostralis, another enclosing the tympanum, and black spots on the flanks; limbs with narrow black cross-bars; thighs marbled with black and white (yellow in life); below whitish, throat speckled with grey.

Vocal sacs showing externally as longitudinal folds on either side of the angle of the jaw, and a grey nuptial pad on the first finger; nasal bones separated on the mid-line; omosternum notched at the base; terminal phalanges swollen.

Dimensions.—From snout to vent 53; breadth of head 18; eye 6; hind-limb 92; foot 28 mm.

Variation.—Eight specimens (7 ♂ ♂, 1 ♀; Nos. 8862 to 8867 and 8870 to 8871) examined, all from the type-locality. Except for slight variations in the size of the tympanum, the interorbital breadth and the length of the hind-limb, they do not differ from the above description. The grey of the upper parts may be pale or quite dark.

Rana timorensis appears most nearly related to *R. microdisca* Boettger and *R. palavanensis* Boulenger. The former has a longer hind-limb and shorter web to the toes and (the male) a larger head, bony prominences in the lower jaw, and no vocal sacs. *R. palavanensis* has a shorter web to the toes, is much smaller in size, and (the male) has internal vocal sacs only. The Indo-Chinese *R. nigrovittata* Blyth is also closely related to it.

I found this new species in a large pit where rain-water had collected; the males had a soft and not unmusical cry. It was obtained also at Soë, where many young just leaving the water as well as adults were found.

Genus Rhacophorus.

Rhacophorus, Kuhl & Van Hasselt, Isis, 1822, p. 475; Schlegel, Isis, 1827, p. 294; Van Kampen, Amphib. Indo-Austral. Archipel., p. 242 (1923).

Polypedates, Stejneger, Herpet. Japan, p. 143 (1907), and Proc. U.S. Nat. Mus., vol. lxvi. p. 29 (1925).

I cannot agree with Dr. Stejneger in his defence of *Polypedates* versus *Rhacophorus*. Here is the original quotation from 'Isis,' 1822:—"Und 2 andere neue Batrachier, welche ein eigenes genus bilden, welches den Hylen am Nächsten steht, aber durch Kopfbildung und kantige Lappen zwischen der Rück- und Unterseite der Extremitaten und des ganzen Habitus abweicht. Wir nennen es *Rhacophorus* die eine Art *Rheinwardti*, weil auch Herr Rhinwardt diess Thier gesehen hat, die andere *moschata*, weil sie einen starken Bisamgeruch weit verbreitet."

"kantige Lappen" evidently refers to the dermal fringe along the outer borders of the fore- and hind-limbs. As a generic description it is as good as most of those given at that period, while it is clear also that, as a genus, it was differentiated from *Hyla*, and that neither of the species included in it are referable to *Hyla*. The *Hyla palmata* to which Dr. Stejneger refers was not mentioned until 1827. The fact that *Rhacophorus reinwardtii* had not been described at the time is immaterial, as Schlegel, in giving his description of it later, mentions that it is the frog referred to by Kuhl and Van Hasselt.

9. Rhacophorus monticola.

Van Kampen, Amphib. Indo-Austral. Archipel., p. 261.

12 specimens from Djikoro, Mt. Bonthain.

The types are from Loko, a few miles distant.

Colour in life.—Bright green above, the flanks spotted and marbled with golden-yellow. A stripe of the same colour on the outer side of the fore-arm and on the leg from the heel to the toe. Supra-anal fold, ventral surface of thighs, palms of hands, and soles of feet yellow; belly white. Two specimens were coloured somewhat differently; in one the back was dappled with grey, in the other it was of a brownish colour with large irregularly-shaped dark spots, as figured by Boulenger in P. Z. S. 1897, pl. xvi.

The largest male is 38 mm. from snout to vent, the largest female 46 mm. All the specimens were caught beside a stream running through a wooded valley.

Tadpoles which I obtained agree with Van Kampen's description. Whether they belong to *R. monticola* or the closely-allied *R. edentulus* I am unable to decide.

10. Rhacophorus edentulus.

Van Kampen, Amphib. Indo-Austral. Archipel., p. 259.

5 specimens. Djikoro, Mt. Bonthain.

They were caught in company with the preceding species, from which they can be distinguished by the feebly-developed vomerine teeth, the shorter web between the outer fingers, and the coloration. My specimens were bright green in life, the back marked all over with black, punctiform spots; below white. In spirit specimens these spots stand out more clearly than in life.

11. Hyla everetti. (Pl. I. fig. 2.)

Van Kampen, Amphib. Indo-Austral. Archipel. 1923, p. 51.

I found this species at Djamplong and also at Soë in small ponds formed by the rain-water. In the latter locality it was fairly plentiful, and was met with in such diverse situations as the open hillside, among rocks, and on the tops of high trees, from where I could hear it calling on rainy evenings. During a heavy storm I caught numbers in a small pond near the rest-house, being attracted to the spot by their vociferous croakings.

The male has a large subgular vocal sac. The size of the tympanum varies, and may be a little smaller or a little larger than the digital disc of the third finger. The tibiotarsal articulation may reach to the tip of the snout.

The tadpole is large and very similar to that of *H. infrafrenata*.

Description.—Length of head and body twice its breadth, body rounded; nostrils nearer to the tip of the snout than the eyes, which are lateral; spiraculum on the left side of the medioventral line, midway between the lower lip and the end of the body, semitubular in form, the external opening being a transverse slit; vent dextral, the opening being above the lower border of the subcaudal crest. Tail about one and a half times as long as the head and body, two and a half times as long as high, acutely pointed; crests convex, the upper starting just behind the head, not as high as the lower.

Mouth subterminal; lips bordered with a single fringe of papillæ, except in the middle of the upper lip, where there is a gap; jaws broadly edged with black; upper lip with two rows of teeth, the inner broadly interrupted by the beak; lower lip with three rows, the innermost narrowly interrupted and a little shorter than the second, the outer very short, often absent.

Colour.—Olivaceous with darker spots and markings.

Dimensions of a specimen with the hind-limbs well developed.—Total length 63; length of head and body (to base of muscular part of tail) 23; height of tail 15 mm.

12. Oreophryne variabilis.

Van Kampen, Amphib. Indo-Austral. Archipel., p. 112.

8 specimens. Peak of Bonthain, 5000–6000 feet altitude.

They were found in rotting wood and beneath fallen tree-trunks.

O. variabilis has been distinguished from *O. celebensis* in having

a larger tympanum and shorter hind-limb. The size and distinctness of the former is variable, but the length of the leg appears consistent, and is sufficient to distinguish the two species.

The pectoral girdle of *O. variabilis* does not differ from that of *O. celebensis*, which has been figured by Mehely (Termész. Füzetek. 1901, pl. x.).

The *S. variabilis* (=*O. variabilis*) recorded from Ravenshoe, N. Queensland (P. Z. S. 1923, p. 1071) I believe to be a species of *Hylophorbus*, but the specimen is badly preserved and cannot be determined satisfactorily.

LIZARDS.

13. Draco beccarii.

Draco beccarii, De Rooij, Rept. Indo-Austral. Archipel., ii. p. 77.

Draco walkeri, Bouleng. Ann. Mag. Nat. Hist., (6) vii. 1891, p. 279 ; De Rooij, Rept. Indo-Austral. Archipel., ii. 1915, p. 75.

11 ♂♂, 6 ♀♀. Djikoro, Mt. Bonthain.

This lizard was common on trees in open jungle and was easily captured ; the females were always accompanied by males.

I have examined the types and only known specimens of *D. walkeri* from Kupang, Timor, and can find no character, except a slightly narrower snout, by which to distinguish them from *D. beccarii*. The tympanum is variable; it may be naked or encroached upon by surrounding scales and completely covered.

Boulenger's plate of *D. beccarii* in P. Z. S. 1897 is an excellent reproduction of the colours in life.

14. Varanus timorensis.

De Rooij, Rept. Indo-Austral. Archipel., i. p. 152.

3 specimens. Djamplong and Lelogama, S. Timor.

This Monitor is a good tree-climber and may be found long distances from water. Those that I caught were not aggressive and did not attempt to bite when handled.

15. Peropus mutilatus.

Gehyra mutilata, De Rooij, Rept. Indo-Austral. Archipel., i. p. 41.

Gehyra beebei, Annandale, Rec. Ind. Mus., ix. 1913, p. 306.

One male example. Kupang, S. Timor.

I have not examined the type of *Gehyra beebei* Annandale, but I can find nothing in the description to separate it from *P. mutilatus*, in which a more or less distinct fold of skin along the side of the body is usually present.

16. Mabuya multifasciata.

Mabuia multifasciata, De Rooij, Rept. Indo-Austral. Archipel., i. p. 162.

Mabuia rudis, De Rooij, ibid. p. 161.

Specimens from Djikoro and Maros in the Celebes and from Lelogama, S. Timor.

M. rudis has been separated from *M. multifasciata* on the following characters:—

M. multifasciata.	*M. rudis.*
Hind-limb not reaching the axilla.	Hind-limb reaching the axilla or beyond.
Subdigital lamellæ smooth.	Subdigital lamellæ keeled.
30 to 34 scales round the body, dorsals and laterals keeled or nearly smooth.	30 to 36 scales round the body, dorsals and laterals strongly keeled.

None of these appear to me sufficient when tested by the large series of specimens now in the British Museum, intermediate examples, which it is impossible to assign to either form, occurring frequently.

The types of *M. rudis* are from Matang, Borneo, and the majority of specimens from North Borneo agree in showing that a longer-legged and more strongly-keeled form exists in that region; but the same characters occur also in occasional specimens from widely-separated parts of the Malay Archipelago, so that the name as applied to a geographical race in its strict sense cannot be used.

17. Lygosoma (Sphenomorphus) variegatum.

Lygosoma variegatum, De Rooij, Rept. Indo-Austral. Archipel., i. p. 196.

Very common on Mt. Bonthain in the neighbourhood of Djikoro; I obtained it also near Maros.

In my series the number of scales round the body varies from 38 to 44. This is greater than the range given by Boulenger or De Rooij.

18. Lygosoma (Sphenomorphus) florense.

Lygosoma florense, De Rooij, Rept. Indo-Austral. Archipel., i. p. 173.

7 specimens. Lelogama, S. Timor.

42 to 46 scales round the middle of the body, 25 to 32 lamellæ under the fourth toe.

Belly greenish in life, sides of throat and upper lip sometimes brick-red.

Diurnal in habits and very active, climbing trees and rocks and entering water.

19. Lygosoma (Omolepida) antoniorum *, sp. n.

Description of the Type.—Adult, author's number 8842. Collected at Lelogama, S. Timor.

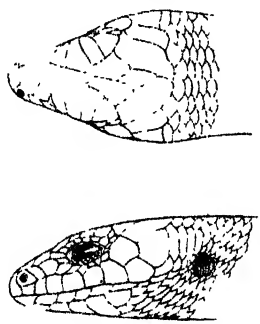
Snout obtuse; lower eyelid scaly; ear-opening oval, as large

* Named after the natives of Timor, who call themselves the Antoni.

as the eye-opening; no lobules. Nostril in the nasal, no supranasal; frontonasal broader than long, in good contact with the rostral, which is rounded above; frontal as long as the frontoparietal and interparietal together, just touching the fronto-nasal, as broad as the supraocular; four supraoculars, the second largest, the first two in contact with the frontal; seven supraciliaries; frontoparietal as long as the interparietal; parietals in contact; no nuchals; an elongated temporal shield; seven supralabials, the fifth below the middle of the eye; two loreal shields one behind the other.

Distance between the snout and the fore-limb once and a half in distance between the axilla and groin. 28 scales round the middle of the body, dorsals largest, all quite smooth; præanals enlarged. Tail thick, one and a half times as long as the body;

Text-figure 3.



Lygosoma antoniorum.

limbs short, the adpressed limbs fail to meet by the length of the foot; 16–17 lamellæ beneath the fourth toe.

Brown above, with indistinct dark, longitudinal lines; flanks speckled with black and white, the black spots closest on the dorsolateral line; lips with dark spots; below whitish (yellow in life).

Length of head and body 55 mm.

Variation.—Eleven specimens (Nos. 8840–8850) were caught, all in the one locality. They show the following variations. Eight have 28 scales round the body, two have 30, one has 32; the subdigital lamellæ vary from 15 to 19; the præfrontals just touch one another or just fail to meet; a pair of nuchals may be present.

Very closely allied to *Lygosoma unilineatum* De Rooij; differing in the absence of auricular lobules, smaller size, and coloration.

Found under stones in damp places. Its habits are crepuscular.

20. LYGOSOMA (SIAPHOS) INFRALINEOLATUM.

Lygosoma infralineolatum, De Rooij, Rept. Indo-Austral. Archipel., i. p. 269.

7 specimens, Djikoro, Mt. Bonthain; 1 specimen, Maros.

This small Scink was common at Djikoro, hiding beneath stones in the open country. Compared with specimens from N. Celebes the limbs are distinctly shorter. In the type from the Sanghi Islands the hind-limb reaches the wrist; in specimens from N. Celebes (Buol, Menado, Kema) the adpressed limbs just touch*. In all of my specimens (adult) they fail to meet, sometimes by as much as the length of the hand. This degeneration of the limbs has been accompanied by a reduction in the number of subdigital lamellæ; in my series they vary from 14–17 beneath the fourth toe.

The eggs of this lizard are large (average size 13 × 8 mm.), and covered with the usual parchment-like skin. They are laid beneath stones, and the young on emerging measure about 42 mm. in total length, with a head and body of 19 mm. The production of three black bands down the back in the place of four is caused by fusion of the two middle ones into a single broad band.

21. LYGOSOMA (LEIOLOPISMA) SPINAURIS, sp. n.

Description of the Type.—Adult, author's number 8853. Collected at Lelogama, S. Timor.

Snout obtuse, lower eyelid with a transparent disc; ear-opening as large as the eye-opening, with pointed lobules all round its border, the anterior the largest. Nostril in the nasal; no supranasals; frontonasals broader than long, in broad contact with the rostral and the frontal; frontal a little shorter than the interparietal, as broad as the supraoculars; four supraoculars, the second longest, the first two in contact with the frontal; six supraciliaries; frontoparietal single: interparietal small; parietals in contact; two loreals, one behind the other; seven supralabials, the fifth longest and below the eye; a pair of nuchals and an elongated temporal.

Distance between the snout and the fore-limb once and a third in distance between the axilla and groin. 30 scales round the middle of the body, subequal; dorsals and laterals with three strong keels; præanals enlarged. Tail as long as the head and body. The hind-limb reaches the elbow; digits moderate, fingers four, toes five, 24 lamellæ beneath the fourth toe.

Colour.—Dark brown above; an indistinct light dorsolateral line bordered with black outside; below whitish; throat spotted with black.

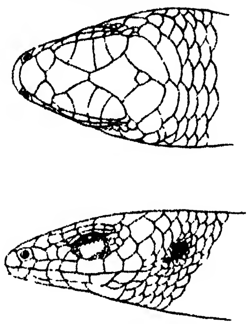
Length of head and body 40 mm.

Variation.—Four specimens were taken in the type-locality (Nos. 8853–6), one at Djamplong (No. 8809), and one at Soë

* Taylor states that the adpressed limbs meet in specimens from the Philippine Islands ('Lizards of the Philippine Islands,' 1922, p. 218).

(No. 8882). All have 30 scales round the middle of the body. The number of subdigital lamellæ varies from 22 to 25, except in the example from Soë, which has 25 to 28. The central keel may be absent, so that the scale is bicarinate. In the example from Soë there is, in addition to a very distinct light dorso-lateral line, another along the flank from the tympanum to the groin.

Text-figure 4.



Lygosoma spinauris.

L. spinauris is allied to *L. fuscum* (Dum. & Bibr.) and *L. bicarinatum* (Macleay). From the former it differs in the shorter hind-limb, the fewer and more strongly-keeled scales round the body, fewer lamellæ beneath the fourth toe, and smaller size. From *L. bicarinatum* it differs in the shorter hind limb, and in the dorsal scales not being mucronate.

This new Scink was found among rocks and grass in open patches of country. Its habits are diurnal.

22. Ablepharus boutoni var. furcata.

M. Weber, Zool. Ergebn. Reise N.O. Ind., i. 1890–91, p. 174.

2 specimens. Endeh, Flores.

This small Scink was not uncommon on the tree-trunks in some dry jungle near Endeh, but so extremely active in its movements that I was only able to secure two specimens.

SNAKES.

23. Typhlops polygrammicus.

Boulenger, Cat. Sn. Brit. Mus., i. p. 34, 1893.

5 specimens. Soë, S. Timor.

The type-specimen is from Timor and is in the Leiden Museum. Dr. Lidth de Jeude has examined it for me, and reports as follows:—The nasal shield is incompletely divided, the lower cleft proceeding from the junction of the first and second labials, the upper extending upwards for a short distance and then

stopping. In my series the cleft varies in position and in extent. The lower portion may proceed as in the type or from the second labial, while the upper may be incomplete (as in the type) or may have the tip curved forwards and touch the rostral, thus making the nasal shield completely divided.

In nine specimens from N. Australia in the British Museum the cleft proceeds from the first supralabial and does not curve at the tip to join the rostral. It would probably be more correct to give the Australian form a trinomial than to consider it distinct. For this Gray's *nigrescens* is available.

24. Cylindrophis celebensis, sp. n. (Pl. II. fig. 4.)

Description.—Type female, unique, author's number 8524. Collected at Djikoro, Mt. Bonthain.

Diameter of the eye half its distance from the mouth, two-fifths its distance from the nostril; distance between the eyes greater than the distance between the snout and the anterior border of the eye; rostral higher than broad, well visible from above; nasals forming a suture; frontal shorter than its distance from the end of the snout, broader than the supraocular, much larger than the parietals; six supralabials, the third and fourth touching the eye; six infralabials, the third largest; three infralabials in contact with the anterior pair of sublinguals; no posterior sublinguals.

Scales in 17 rows on the neck, 19 at mid-body, and so continued to the vent. Ventrals 254, a little broader than the adjacent scales; anal divided; subcaudals 8, broader than the ventrals; tail obtuse, broader than the head.

Colour.—Bluish-black above, highly iridescent; whitish below (crimson in life), the scales tipped with black and with black cross-bands which extend completely across the belly or alternate on the mid-line with those of the opposite side. Head black, with a whitish band across the snout and a blotch of the same colour behind the eye; lower jaw white, with a median black stripe extending forwards from the first band across the throat.

Total length 480; tail 16 mm.

Very closely related to *C. boulengeri* Roux, from which it differs in the smaller frontal, broader ventrals and in the coloration of the head.

I caught this very beautiful snake early one morning as it was crossing a mountain-path. It made no effort to escape and was quiet to handle. It had the same habit as *C. rufus* of flattening the body when alarmed and curling the tip of the tail upwards so as to show the red colour underneath.

25. Natrix celebicus.

Tropidonotus celebicus, De Rooij, Sn. Indo-Austral. Archipel., p. 78.

5 specimens. Mt. Bonthain, 1500 metres.

3 ♂. V. 142–143. C. 57–62.
2 ♀. V. 145–146. C. 52–(?).

The specimens were caught beneath stones on the mountain-side. The following variations can be added to the description:—Loreal as long as high or longer than high; internasals as long as or shorter than the præfrontals; temporals 1/1+2. None of my specimens has longitudinal stripes.

26. NATRIX SARASINORUM.

Tropidonotus sarasinorum, De Rooij, Sn. Indo-Austral. Archipel., p. 79.

1 ♀ ex. (No. 8625) from Djikoro, Mt. Bonthain.

Maxillary teeth 27, the posterior gradually enlarging. V. 146, C. 64. In lepidosis and in coloration it agrees well with the two specimens, the types, already known. A Scink, *L. variegatum*, was found in the stomach.

27. ELAPHE SUBRADIATA.

Coluber subradiatus, De Rooij, Sn. Indo-Austral. Archipel.

6 specimens. Djamplong, Soë, S. Timor.

Scales 25. 23. 19.—4 ♂. V. 142–148. C. 92–96.
„ „ „ „ 2 ♀. V. 242–244. C. 92–94.

Nine supralabials are constant in all the specimens. No. 8915 has the fourth supralabial undivided on one side; in all the others it is divided by a horizontal suture. Like *E. radiata* this snake has the power of dilating its neck in a vertical direction, but is of a gentle disposition and allows itself to be handled quietly when captured.

28. LYCODON AULICUS.

De Rooij, Sn. Indo-Austral. Archipel., p. 111.

7 examples. S. Timor (Djamplong, Soë).

5 ♂. V. 188–192. C. 67–72.
2 ♀. V. 191–203. C. 68.

All specimens of *L. aulicus* from the Indo-Chinese Peninsula south of about Lat. 20° N., and throughout the Malay Peninsula and Indo-Australian Archipelago, have the same colour-pattern, which is as follows:—

Brownish or purplish above with fine white or yellow reticulations; a whitish triangular blotch on either side of the occiput, or the two connected above to form a collar; labials white, some or all of them with a brown spot. In some specimens the reticulations are very indistinct and may be entirely absent (*L. uniformis* Boie).

Specimens from the Indian region have narrow white cross-bars enlarging or bifurcating on the flanks or confined to the back

or to the anterior part of the body only, or the markings may be entirely absent.

Specimens from Upper Burma and adjacent territory show either form of coloration or have a combination of the two.

The number of ventral and subcaudal shields varies but little over the whole range of the species, as the following table will show:—

Ceylon	V. 179–204.	C. 57–67.	12 specimens.
South and Central India	V. 178–210.	C. 59–70.	8 ,,
N.E. India	V. 183–214.	C. 62–80.	11 ,,
Siam and Indo-China	V. 185–202.	C. 62–74.	10 ,,
Malay Penin. and Archipelago	V. 183–207.	C. 66–72.	12 ,,
Philippine Is.	V. 194–210.	C. 62–78.	22 ,,

29. Dendrophis pictus timorensis, subsp. n.

A race of *D. pictus* agreeing with the typical form in scale-characters, but differing in coloration, the lateral stripes of yellow and black being entirely absent. The coloration is as follows:—Olive above, greenish-yellow below, the two colours merging imperceptibly into one another on scale-rows 1 and 2. A dark streak from the posterior border of the eye passing on to the neck. The maxillary teeth are 22 in number in the type-specimen (No. 8810).

Details of Specimens examined.

No. 8810, ♀	V. 195.	C. 153.	Djamplong.
8830, ♂	V. 189.	C. 139.	Lélogama.
8883, ♂	V. 188.	C. 142.	Near Soë.
8918, juv.......	V. 186.	C. 150.	Soë.
8919, juv.... ..	V. 188.	C. 130 (imperf.).	Soë.

30. Oligodon wandersi.

Boulenger, Cat. Sn. Brit. Mus., ii. p. 245; De Rooij, Sn. Indo-Austral. Archipel., p. 133.

7 examples. Djikoro, Mt. Bonthain.

♂.			♀.		
No. 8526 ...	V. 154.	C. 23.	No. 8525 ...	V. 165.	C. 21.
8527 ...	V. 156.	C. 25.	8641 ...	V. 157.	C. 25.
8550 ...	V. 156.	C. 25.	8707 ...	V. 167.	C. 24.

No. 8701, juv. ...... V. 168. C. 23.

Eight maxillary teeth, the last two very strongly enlarged; palatine toothless, pterygoid with 6 or 7 small teeth on its posterior half. Mandible with 6 small teeth. Six supralabials, no loreal, and a divided anal shield occur in each example. In lepidosis they agree entirely with Boulenger's description as given in the Catalogue, and not with that given by De Rooij.

Colour in life.—Dark brown above, the two immature examples with a distinct series of small, lateral, orange, black-edged spots arranged in pairs alternating with a single series of vertebral spots. In the adults these marks have disappeared. Below whitish, uniform, or with small dark spots. A dark patch with a yellow band behind on the nape disappearing in the adult.

31. Boiga irregularis.

De Rooij, Sn. Indo-Austral. Archipel., p. 201.

1 ♀. Lowah, S. Celebes.

Scales in 21 rows. V. 264, C. 127 pairs.

Colour in life.—Pale greenish-brown anteriorly, reddish-brown posteriorly, with narrow black cross-bands which disappear on the hinder part of the body. A dark streak behind the eye; throat and anterior part of belly white, posterior part dull rose; tail with dark mottlings.

Calamaria species.

The genus *Calamaria*, as it is known at present, consists of a large number of forms, most of them differing in small characters only and yet apparently always quite distinct from one another. Every year their number increases; for each new locality collected in seems to produce a form peculiar to itself, and the grand total when the regions inhabited by the genus are thoroughly known will be very large indeed. In the hope that large series from one locality would throw some light on the relationships of these closely-allied forms, I collected *Calamaria* extensively while on Mt. Bonthain, where these snakes were common. The result showed each species to be extremely constant. The lepidosis of the head (except in one specimen of *C. apræocularis*) showed no variation, and, when the sexes were considered separately, there was but little variation in the number of the ventral and subcaudal shields. The usual method of recording the variation without regard to sex gives a misleading view of what actually obtains.

The following key will serve to distinguish the South Celebesian forms, all of which agree is having five supralabials, the third and fourth touching the eye, and in having the mental shield in contact with the sublinguals. In these characters they differ from the three species known from North Celebes:—

A præocular; ventrals not more than 180.
  Frontal much shorter than parietal.
    Snout pointed .... *acutirostris.*
    Snout rounded .... *curta.*
  Frontal as long or nearly as long as the parietals.
    V. 146–155, C. 17–20 (♂); no light spots on the neck or tail .... *mülleri.*
    V. 133, C. 16 (♂); light spots on the neck and tail ...... *nuchalis.*
A præocular; ventrals 210–240 .... *gracilis.*
No præocular .... *apræocularis.*

32. CALAMARIA ACUTIROSTRIS.

De Rooij, Sn. Indo-Austral. Archipel., p. 160.

10 specimens. Djikoro, Mt. Bonthain.

5 ♂. V. 154–158. C. 22–24.
5 ♀. V. 166–168. C. 16–17.

The specimens were caught beneath stones. Colour in life dark grey above, highly iridescent, white below.

33. CALAMARIA CURTA.

De Rooij, Sn. Indo-Austral. Archipel., p. 160.

4 specimens. Peak of Bonthain.

No. 8754, ♂. V. 155, C. 23; No. 8753, ♀. V. 156, C. 16; No. 8755, ♀. V. 169, C. 16; No. 8756, ♀. V. 170, C. 16. Type ♀. V. 154, C. 15.

The type and until now only known specimen was collected by Everett in S. Celebes at an altitude of 2000 feet. My specimens were caught at between 5000 and 6000 feet altitude, and the fact that none was found lower down on the mountain, where *C. mulleri* was common, suggests that Everett's altitude may be incorrectly stated. The species is closely allied to *C. mulleri*, from which it differs in having a larger parietal (much longer than the frontal), a much smaller rostral, and a longer anal shield. The two are quite distinct from each other.

I found these small snakes beneath, and in the cavities of, rotting, fallen tree-trunks. Their diet consisted of worms.

34. CALAMARIA MULLERI.

De Rooij, Sn. Indo-Austral. Archipel., p. 161.

Djikoro, Mt. Bonthain.

14 ♂. V. 146–155. C. 17–21.
16 ♀. V. 163–178. C. 12–15.

Two more or less distinct types of coloration in life were observed. One was reddish-brown above, light or dark orange below; the other dark grey above, yellowish below.

The types of *C. mulleri* are from Mt. Bonthain. The characters given by Boulenger to separate this species from *C. nuchalis*, at present known only from the type-specimen (♂), break down when applied to the large series obtained by me. The species, however, appears to be distinct upon the number of ventral shields and the coloration.

35. CALAMARIA APRÆOCULARIS, sp. n.

Description of the Type.—Adult female, author's number 8542. Collected at Djikoro, Mt. Bonthain.

Body long and slender, snout rounded; diameter of the eye slightly less than its distance from the mouth. Rostral broader than high; frontal a little longer than broad, nearly three times

as broad as the supraocular, much shorter than the parietals; no præocular; a postocular; five supralabials, the third and fourth touching the eye, the fifth much the longest; five infralabials, three of which and the mental are in contact with the anterior pair of sublinguals, which are larger than the posterior.

Scales in 13 rows; ventrals 217, rounded; anal undivided; subcaudals 10 pairs; tail ending in a point.

Colour.—Grey above, the tips of scale-rows 1 to 3 whitish; ventrals grey, the free margin whitish; labials white.

Variation.—In No. 8752 the second and third supralabials on the right side are united to form a single shield.

Calamaria apræocularis is one of the few species in which the præocular shield has disappeared; it appears nearest to *C. schlegeli* Dum. & Bibr., from Borneo and Sumatra, from which it differs in the more slender body, the greater number of ventral shields, and in coloration.

Details of Specimens examined.

Number.	Sex.	Total length.	Tail.	Ventrals.	Caudals.
8542	♀.	285 mm.	12 mm.	217	10
8752......	♀.	240 ,,	9 ,,	220	9
8640......	♂.	150 ,,	11 ,,	175	18
8691......	♂.	152 ,,	12 ,,	188	18

I found these small snakes under stones upon the open hill-side. Their diet consisted of worms.

36. Trimeresurus gramineus.

Lachesis gramineus, De Rooij, Rept. Indo-Austral. Archipel., p. 285.

6 specimens. S. Timor.

No. 8799, ♂	V. 162.	C. 72.	Kupang.
8795, ♀	V. 166.	C. 58.	,,
8796, ♀	V. 167.	C. 57.	,,
8813, ♀	V. 164.	C. 56.	Djamplong.
8827, ♀	V. 165.	C. 55.	Lélogama.
8828, ♀	V. 165.	C. 58.	,,

21 scale-rows at mid-body occur in all. No. 8795 has the second and third, and No. 8796 the third to seventh, subcaudals single. No example has a lateral line.

EXPLANATION OF THE PLATES.

Plate I.

1. ***Rana microtympanum*** (nat. size).
2. Tadpole of ***Hyla everetti*** (nat. size).

Plate II.

1. ***Rana timorensis*** (nat. size).
2. ***Rana arathooni*** (nat. size).
3. ***Oxidozyga semipalmata*** (nat. size).
4. ***Cylindrophis celebensis.*** (× 2.)

14. On a New Type of Mammal-like Reptile from the South African Karroo Beds (*Anningia megalops*). By R. Broom, D.Sc., F.R.S., C.M.Z.S.

[Received November 30, 1926; Read March 8, 1927.]

(Text-figures 1–3.)

The specimen which I am about to describe, though only a badly-weathered and imperfect skull, is one of the most important fossils discovered in South Africa for many years. It is a small skull the snout of which has been broken off at the anterior orbital margin and lost, and much of the bones of the posterior portion preserved have been weathered off. Yet notwithstanding these imperfections, enough remains to reveal all the more important characters, and to enable one to restore the whole skull with much confidence.

The specimen was discovered by Mr. W. van der Byl, of Abraham's Kraal, on Mr. Hattingh's farm, about five miles down the Gamka River from Abraham's Kraal, in beds which have yielded *Dicynodon jouberti*, *Pristerognathus vanwyki*, *Galesuchus gracilis*, and *Trochosuchus acutus*, and which are the oldest beds of the Karroo that have hitherto yielded a rich fauna, and near the base of the *Pareiasaurus* or *Tapinocephalus* zone.

As the skull represents not only a new genus, but a new Order of the Therapsida, I propose to call it *Anningia megalops* in honour of Miss Mary Anning, of Lyme Regis. Though many of the finest specimens of fossil reptiles in the British Museum were discovered by Miss Anning, and these specimens formed the basis of much of the work of Home, Conybeare, De la Beche, Hawkins, and Owen, and thus helped to give Britain its high position in the history of vertebrate palæontology, I have long felt that the part played by Miss Anning has not been fully appreciated as one of the world's greatest fossil hunters and as a pioneer. Although it is about a hundred years since she did most of her work, one may perhaps still be allowed to lay a stone on the cairn of this most remarkable woman *.

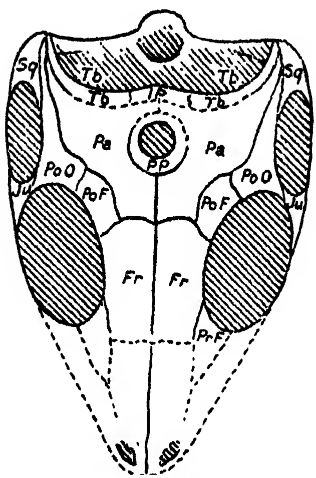
The skull when complete must have measured very nearly 60 mm. in length, and 40 mm. in breadth. The antorbital portion of the skull I estimate to have been 20 mm. As

* When the 'Dictionary of National Biography' was compiled, Miss Anning was evidently not considered worthy of notice; but apparently someone has called attention to the fact that the discoverer of *Ichthyosaurus*, *Plesiosaurus*, and the first known Pterodactyle deserved at least some recognition, and a short account of her life appears in the Supplement.

the posterior two-thirds of each mandible are in undisturbed positions, the position of the symphysis can be determined with considerable accuracy; so that the measurement of the snout I give must be very nearly correct. The antero-posterior measurement of the orbit is 19 mm.

Though the frontals (text-figure 1) are almost completely weathered off, the impressions of the undersides of each bone are nearly perfect, there being only missing a little bit of the front and a small portion of the orbital margin of the right bone. The bones are relatively short, and lie between the upper borders of the orbits. The interorbital measurement is 14 mm. The antero-posterior measurement of the frontals appears to have been about 16 mm.

Text-figure 1.



Upper view of Skull of *Anningia megalops* Broom. Nat. size.

A small part of each prefrontal is preserved. It is manifestly a large bone.

Much of each postfrontal is preserved, but as a good deal of each bone is weathered off, the exact position of the suture between it and the postorbital, as it would appear on the surface, is a little doubtful. It cannot, however, have differed greatly from that I give in the figure. The postfrontal is a relatively small bone fitted in between the frontal, the parietal, the postorbital, and the margin of the orbit.

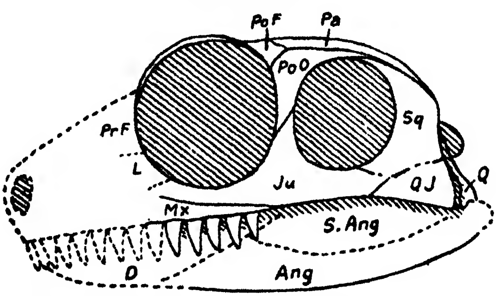
The postorbital is fairly well preserved on each side. It is a triradiating bone. The lower branch forms much of the postorbital arch and passes down to meet the jugal. The posterior branch lies along the outer side of the parietal and

passes back to meet the squamosal. The upper branch, which is the shortest, articulates with the postfrontal.

The parietal is a large broad bone. In front it articulates with the frontal. It surrounds the ring-like preparietal, which completely separates it from the pineal foramen. The outer side of the bone articulates with the postfrontal and the postorbital and passes back to meet the squamosal. Posteriorly it appears to be completely shut off from the occiput by a long narrow Tabular and a short Interparietal. As very little of the bone remains in this posterior region, the sutures are doubtful except such as I have indicated in the figure by an unbroken line.

The preparietal is extremely interesting. It appears to completely surround the large pineal foramen, but it is impossible from the specimen to decide whether there is a pair of bones or only a single ring of bone. Most probably the condition is as I indicate in the figure.

Text-figure 2.



Side view of Skull of *Anningia megalops* Broom. Nat. size.

Though the Tabulars and the Interparietals only form a small part of the upper surface of the skull, they appear to form much of the upper half of the occiput.

The squamosal (text-figure 2) is a relatively large bone which forms the whole of the posterior wall of the temporal fossa. Above, it articulates with the parietal and the postorbital. Posteriorly it articulates with the paroccipital and the quadrate, and inferiorly with the quadrato-jugal.

The quadrate is relatively large and, when viewed from behind, appears as shown in the figure of the occiput. It articulates closely with the quadrato-jugal by a suture.

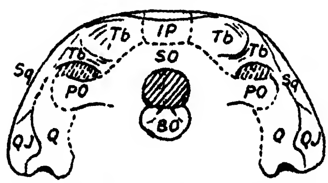
The quadrato-jugal is moderately large, having a deep posterior portion that articulates with the quadrate and a larger facial portion that passes forward below the squamosal to meet the jugal.

The jugal forms most of the lower orbital margin and a large part of the temporal arch. Posteriorly it meets the

squamosal and the quadrato-jugal, superiorly it articulates with the postorbital, and anteriorly it passes above the posterior part of the maxilla to meet the lacrymal.

The occiput (text-figure 3) has not been fully displayed, but most of the structure can be satisfactorily made out. The foramen magnum and the occipital condyle are situated unusually high up, the condyle being much above the level of the articular ends of the quadrates. The paroccipitals pass outwards on the level of the condyle, apparently articulating with the squamosals, the tabulars, and the quadrates. The evidence does not show whether the interparietal is single or paired. It evidently forms a considerable part of the occiput. The tabulars are large, and form the upper and outer portions of the occiput. There is a much thickened portion of bone passing from the middle part of the bone towards the foramen magnum. This thickened portion of the bone seems to be part of the tabular, as indicated in the figure.

Text-figure 3.



Occiput of *Anningia megalops* Broom. Nat. size.

The maxillæ have only their posterior ends preserved. They carry a series of rounded, long, pointed teeth which at their bases are anchylosed to the bone as in *Procolophon*.

The mandibles are rather badly preserved, most of the surface bones having been flaked off. Still, a good deal of the structure can be made out. In all typical Therapsids the mandible is characterized by the very small size of the central cavity, a condition also seen in the Pelycosaurs; but in the more aberrant and primitive Theromorphs the cavity is large, as in *Procolophon* and most Cotylosaurs. In *Anningia* the mandible agrees more with these aberrant American types. Only the posterior parts of the dentaries are preserved, and these posterior portions only form a small part of the jaw, as the angulars are large and form most of the outer side of the middle of the jaw, while on the inside the splenial is almost as deep as the jaw. The angular forms most of the lower side of the posterior two-thirds of the jaw. The surangular is exceptionally large, and forms at least half of the outer side of the posterior half of the jaw.

While it is impossible to fully decide the affinities of *Anningia* till we know more than this imperfect skull, still we can approximate fairly closely to what must be its true position.

There are four or five known types to which it shows affinity in various ways.

It differs very widely from most of our known South African types. In the great width of the parietal region it is seen to be pretty far removed from the Therocephalia, the Dinocephalia, the Bauriamorpha, and the Cynodontia. But there is a distinct suggestion of affinity with the Gorgonopsia and to a less extent with the Anomodontia.

The Gorgonopsians and the Anomodonts agree in having the very remarkable preparietal bone, a bone unknown in any other Therapsids, unless perhaps it occurs in the Dromasaurians. And the presence of this preparietal has suggested that the Anomodonts have sprung from a pre-Gorgonopsian. In *Anningia* we have an undoubted preparietal, and though in surrounding the foramen it is unlike that in any known Gorgonopsian, we know that in some Anomodonts the preparietal also surrounds the foramen. Further, the arrangement of the bones of the whole supra-temporal region resembles more that of the Gorgonopsian than any other known types.

Though the Dromasaurians are specialized in having the squamosal descending to form a deep suspensorium, there is sufficient resemblance between them and *Anningia* to suggest a not very remote descent from a common ancestor. Unfortunately, the detailed structure of the Dromasaurian skull is less satisfactorily known than in *Anningia*.

A number of American types are known which also clearly show affinity with *Anningia*. In 1910, I showed that the South African Therapsids are somewhat distantly related to the American Pelycosaurs, and in 1914, when the structure of the Dinocephalians became better known, I showed that the affinity was perhaps closer than had been suspected. Now the discovery of *Anningia* gives us a new type with clear affinities with some other American forms.

Casea has a skull with a large pineal foramen and a very broad parietal region. Unfortunately, the details of structure are unknown, but most likely they are fairly similar to those of *Anningia*. The orbital and temporal regions are also fairly alike in the two forms, and the mandible probably does not differ greatly in essential structure. The occipital structure, however, differs very markedly in the two types.

In 1914, Williston discovered a new type of Theromorph which he called *Mycterosaurus*. It is a small form not much larger than *Anningia*, and though it differs in having a long snout, it has the postorbital portion of the skull remarkably like that in the South African form. The parietal region differs from that in *Anningia* in having no preparietal, in having a small pineal foramen, and in being not much wider than the prefrontal region. The way in which the tabular and the interparietal border the parietal behind, is very similar in the two genera, and there also seems a fairly close agreement in the occiputs of the two.

Another American form that also seems to have some affinity is *Glaucosaurus*. This is a small animal, smaller even than *Anningia*. Unfortunately, the posterior part of the skull is imperfect. Though having a much shorter snout than *Myctero-saurus*, it agrees sufficiently closely to render it most probable that the two belong to the same Suborder. *Glaucosaurus* agrees with *Mycterosaurus* in having the parietal region not much wider than the prefrontal. The pineal foramen is evidently quite small.

In conclusion, *Anningia* appears to be the most primitive Therapsid yet known. It clearly shows affinities with the Gorgonopsians. Not improbably it is a member of an Order from which originated the Gorgonopsia, the Therocephalia, and the Anomodontia, and possibly also the Dinocephalia. As there is some reason to suspect that both the Cynodonts and the Mammals have sprung from a pre-Gorgonopsian, we may have in *Anningia* a representative of the group that gave rise to not only most of the Therapsids, but also the Mammals. The Dromasaurians are possibly a co-lateral branch.

The important primitive Therapsid Order represented by *Anningia* may be called the Anningiamorpha. It is of great interest in being not only the most generalized and primitive of the Therapsids, but nearly related to the most generalized and primitive of the American Theromorphs. In the genea-logical tree I gave in 1919 in my paper "On the Classification of the Reptiles," I derived the Therapsids from a primitive Pelycosaur. The discovery of *Anningia* fully confirms this view.

Anningia is of further interest in confirming, I think, the view which I have held since 1904 that the temporal fossa in the Mammal-like reptiles is the homologue of the lower fossa seen in *Sphenodon*; whereas the single fossa in the Plesiosaurs and Ichthyosaurs is, I consider, the homologue of the upper fossa. The point is of some importance. By many it has been held that the single fossa in the Plesiosaurs is the homologue of the single fossa in the Therapsids, and that the Plesiosaurs are thus related to the Therapsids and are yet to be grouped with them in the Synapsida. Though by a parallel development the Plesiosaur skull has come to have some superficial resemblance to that of the Therocephalians, the two are, in my opinion, entirely dissimilar in origin; and when once *Anningia* comes to be appreciated as the most primitive known Therapsid, it will be difficult for anyone to believe that the Plesiosaurs are nearly related.

References to Lettering in Figures.

Ang. Angular; *D.* Dentary; *Fr.* Frontal; *I.P.* Interparietal; *Ju.* Jugal; *L.* Lacrymal; *Mx.* Maxilla; *Pa.* Parietal; *PoF.* Postfrontal; *PoO.* Postorbital; *P.P.* Preparietal; *PrF.* Prefrontal; *P.O.* Paroccipital: *Q.* Quadrate; *Q.J.* Quadrato-jugal; *S.Ang.* Surangular; *Sq.* Squamosal; *S.O.* Supra-occiptal; *Tb.* Tabular.

15. Some further points on the Structure of the Mammalian Basicranial Axis. By R. Broom, F.R.S., C.M.Z.S.

[Received December 7, 1926: Read March 8, 1927.]

(Text-figures 4–10.)

In a paper recently published by the Zoological Society * I pointed out that, whereas in our text-books the mammalian basicranial axis is always stated to be composed of four bones—the basioccipital, the basisphenoid, the presphenoid, and the mesethmoid,—in Marsupials and Artiodactyls there are never more than three elements. I further showed that in the Therapsid reptiles from which the mammals have sprung there are also only three elements in the basicranial axis, and that as these three are manifestly homologous with the three in Marsupials and Artiodactyls, and are thus the basioccipital, the basisphenoid, and the presphenoid, that, consequently, the fourth element when present in mammals must be looked upon as a neomorph. Since my paper appeared I have been able to collect some further evidence of an interesting nature.

Perissodactyla.

As I showed that in the Hyrax there is a distinct mesethmoid, while there is none in the Artiodactyls, I was naturally very curious to know what is the condition in the Perissodactyls. I therefore killed a number of pregnant female donkeys and examined the skulls of the fœtuses. I found that till quite late in pregnancy there is no ossification whatever in the internasal cartilage. In a fœtal donkey with a skull-length of 240 mm. the presphenoid is just commencing to invade the septal cartilage. But from this stage onwards the presphenoid rapidly grows into the "mesethmoid" region.

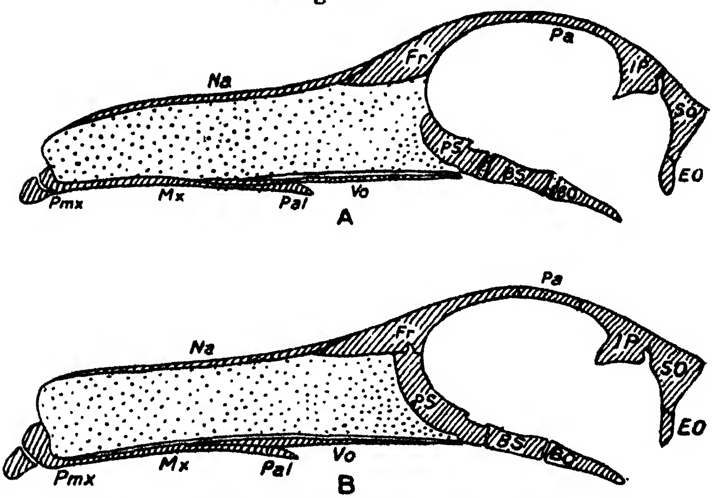
In a fœtus with a skull-length of 280 mm. and which may be regarded as representing the condition at birth, the presphenoid has grown up into the cartilage nearly half-way to the frontal. This skull, of which I figure the median section (text-figure 4 A), will be seen to agree pretty closely with that of the young calf which I figured in my previous paper. There are various minor differences to be seen in the skull, but the basicranial axis agree in the two in practically all details.

The next section which I figure is that of the skull of a young donkey 34 days old (text-figure 4 B). Here the skull measures 327 mm., and though it is thus only a little larger than the skull

* "On the Mammalian Presphenoid and Mesethmoid Bones," P. Z. S. 1926, p. 257.

at birth, the presphenoid has already grown up to meet the frontal and to become closely articulated with it. This section may be compared with the one I gave from a young goat, and the one which Flower gives of the Sheep in his 'Osteology of the Mammalia.' The large anterior bone Flower considers to be mesethmoid anchylosed with the presphenoid, and anyone only having such a stage of the Donkey as the one I figure would naturally conclude that both elements are represented in this large anterior bone. But when a series of earlier stages are examined it is found that in the Perissodactyl donkey there is as in the Artiodactyls no trace at any stage of a mesethmoid element.

Text-figures 4 A & B.



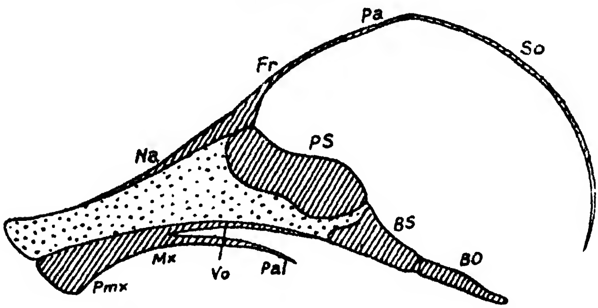
A. Median section of Skull of fœtal Donkey at full term. Skull length 280 mm.
B. Median section of Skull of young Donkey. Skull length 327 mm.

The extremely close agreement in the structure of the basicranial axis in Artiodactyls and Perissodactyls is a point of very great interest. Gill, Flower, Lydekker, and Cope have all agreed in regarding the Artiodactyls and the Perissodactyls as closely allied groups. This view, however, has been opposed by many, and chiefly by the American palæontologists. Gregory, in his great work 'The Orders of Mammals,' discusses the question at length. He says (p. 400): "Aside from the characters of the feet, the Artiodactyla and Perissodactyla possess very few characters in common and these are of a very inconclusive nature (*e. g.*, placenta non-deciduate, uterus bicornuate, testes descending into a scrotum, os penis absent)" . . . "The points of resemblance between the two orders in the limbs are sometimes very striking" . . . (p. 401) "yet in spite of

these resemblances the evidence indicates that the Diplarthra or Ungulata Vera is a wholly unnatural group, that the Artiodactyla and Perissodactyla have been derived from very different sources, and that the resemblances are either primitive protungulate characters or of an entirely convergent nature." He considers that (p. 397) "the derivation of the Perissodactyl order from the general Insectivore-Creodont-Condylarth group of Placentals seems fairly well established." The origin of the Artiodactyls appears much more doubtful, but the group is thought to possibly spring from an unknown Basal Eocene pro-Creodont. But it is held that possibly (p. 406) "not all Artiodactyls have been derived from a pro-Creodont source."

In reply to Gregory, it might be pointed out that while the palæontological evidences for the genetic relationships of the Ungulates are fairly satisfactory as far back as Middle Eocene, the evidences in Lower Eocene times are rather unconvincing,

Text-figure 5.



Median section of Skull of young *Chrysochloris asiatica*. Skull length 20·5 mm.

while those from the Basal Eocene are so scanty that they are possibly entirely misleading. Perissodactyls and Artiodactyls can both be traced back as far as Lower Eocene, but whether we know anything of their ancestors in the Basal-Eocene is extremely doubtful. The fact that all known Carnivores and Insectivores have a mesethmoid, while the Artiodactyls have not, would certainly lead one to doubt the palæontological evidence that would ally the Artiodactyls rather with Carnivores and Insectivores than with the Perissodactyls. The striking resemblance of the structure of the basicranial axis in Artiodactyls and Perissodactyls is certainly a fact that demands serious consideration. I doubt if such a similarity could have been brought about by convergence.

Chrysochloridea.

In 1915 when examining the Organ of Jacobson in the "Insectivores" I discovered * that *Chrysochloris* differed entirely

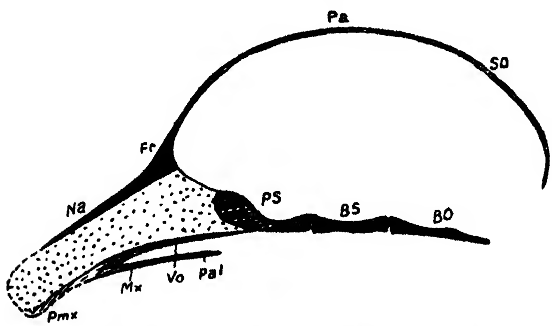
* "On the Organ of Jacobson and its Relations in the Insectivora.—Part II. *Talpa*, *Centetes*, and *Chrysochloris*." P.Z.S. 1915, p. 347.

from all typical Insectivores, and also from the Menotyphlous genera *Macroscelides* and *Tupaia*, and that it must be placed in an Order by itself—the Chrysochloridea,—a conclusion that had to some extent been foreshadowed by Dobson. It therefore became a matter of much curiosity to see if *Chrysochloris* has a mesethmoid bone; and, fortunately, I had in my collection a specimen of a young *Chrysochloris asiatica*.

On making a median section of the head (text-figure 5) I found that *Chrysochloris* differs from all known Insectivores, and also, as I will show presently, from the Menotyphla as represented by *Macroscelides*, and agrees with the Marsupials and Ungulates in having no mesethmoid bone.

Fortunately the specimen is young enough to show the sutures between the basioccipital and basisphenoid and between the basisphenoid and the presphenoid. The figure I give shows the shapes and relations of the bones.

Text-figure 6.



Median section of Skull of young *Cycloturus* sp. Skull length 36 mm.

Two earlier skulls I have cut in sections. The earlier one is that described by me* in 1916. Here the presphenoid is still unossified. The later stage has the presphenoid fairly well ossified and invading the septal cartilage. But there is no mesethmoid.

The absence of a mesethmoid completely confirms the view that *Chrysochloris* and the nearly allied genera ought to be removed from the Insectivora and placed in an Order by themselves.

Cetacea.

Notwithstanding the large number of specimens of young Cetaceans that must have been in the collections of so many museums, it is rather remarkable that we have no certain information as to whether a mesethmoid bone occurs in the

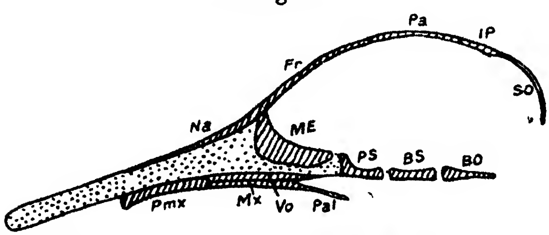
* "On the Structure of the Skull in *Chrysochloris*." P. Z. S. 1916, p. 449.

Whale tribe or not. Doubtless the reason is that while a very young fœtus can be preserved in spirit or formalin, a third- or half-grown Cetacean would be a most troublesome specimen to preserve either in the flesh or as an osteological specimen.

In the Royal College of Surgeons' Museum there is the skull of a young *Globicephalus melas* which is figured by Flower. Concerning this skull Mr. Burne writes me—"There is in this skull no sign of division between the presphenoid and mesethmoid."

Recently a young (either fœtal or new born) Porpoise was received by the Museum from Plymouth, and Mr. Burne sectioned the skull and states—"It shows no indication of a separate mesethmoid element. It looks very much like your diagram of the calf in the P.Z.S. for 1926." This specimen Mr. Burne has kindly sent me, but, unfortunately, he has only sent the base showing the basioccipital, basisphenoid, and presphenoid. Very certainly there is no mesethmoid at this stage, and I think it unlikely that one occurs at a later stage.

Text-figure 7.



Section of Skull of young *Macroscelides rupestris*. Skull length 35 mm.

Flower figures (fig. 63) a section of the skull of a fœtal *Balæna*. This shows the basioccipital, basisphenoid, and presphenoid all well ossified, but no trace of a mesethmoid. Flower states: "No part of the mesethmoid is ossified." And from the appearances in this and other specimens, it seems to me probable that no mesethmoid is developed.

Dr. Gill, of Capetown Museum, has sent me on loan a skull of a young Dolphin about half-grown. Here the front of the brain-cavity is formed, as in the *Globicephalus* figured by Flower, by a single large presphenoid which shows no evidence of its being in part mesethmoid. And though Flower marks the upper part of the bone "mesethmoid," as he does in the case of the Sheep's skull, I think further investigation will show that the bone in the Cetacean is, as we know to be the case in the Sheep, entirely presphenoid.

I trust some one who has the opportunity will look into the matter. A few stages between birth and the half-grown state would give us the facts we want to know. It is a matter of considerable importance.

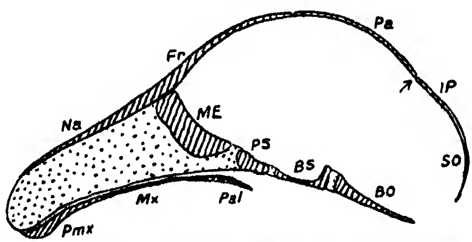
Concerning the origin of the Whales we know very little. Affinities have been suggested with the Artiodactyls, with the Insectivores and Creodonts, and with the Edentata. If it be conclusively shown that no mesethmoid is ever developed, as appears probable, the case for an Artiodactyl or Edentate affinity will be strengthened. If a small mesethmoid is discovered the case for an Insectivore or Creodont affinity will be almost proven.*

PROBOSCIDEA and SIRENIA.

Too few specimens of young skulls of Elephants and Sirenians are at present known to enable us to say with any confidence whether a mesethmoid is present or not.

There is a young Elephant skull in the Royal College of Surgeons' Museum, London, which has been sectioned in the middle line and figured by Flower in his 'Osteology of the Mammalia.' I wrote to Sir Arthur Keith concerning this and one or two other skulls, and he has asked Mr. R. H. Burne to

Text-figure 8.



Median section of Skull of young *Epomophorus wahlbergi*, a Fruit-Bat. Skull length 30 mm.

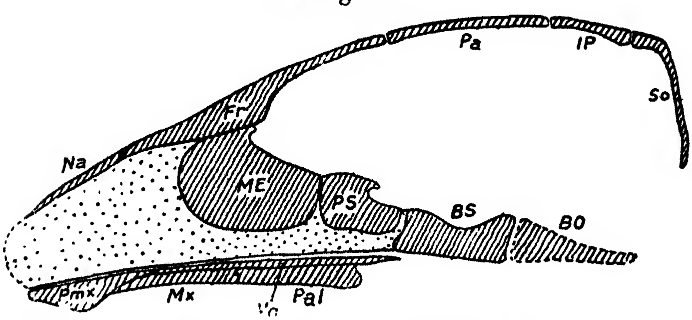
examine the skull and report to me. This Mr. Burne has most kindly done, and though the skull fails to give a conclusive answer to our question, the more important parts of his report must be quoted. "The young skull figured by Flower (Osteol. p. 181, fig. 59) is in the Museum. 'No. 2495 *Elephas africanus*, a longitudinally and vertically bisected skull of a very young animal.' The figure, which is not very good, is apparently of the left half reversed. There is no indication of a separation between the presphenoid and mesethmoid." There is in the specimen a suture which runs backwards and inwards from the front of the orbitosphenoid to the middle line, and of

* 28.2.27. Prof. W. K. Gregory of New York has just sent me a drawing of a median section of the skull of a young *Monodon monoceros* (probably not more than three months old) made by Mr. H. C. Raven of the American Museum. The specimen shows conclusively that in *Monodon* there is no trace of a Mesethmoid bone, a large Presphenoid occupying the whole space from the nasal above to the vomer below. We may thus I think safely conclude from all the evidence we have from a considerable number of young Cetaceans of different genera that the Cetacea agree with the Artiodactyls in having only three bones in the basicranial axis, and never a Mesethmoid.—R. B.

which Mr. Burne has sent me two drawings. "The suture penetrates some little way into the bone, and meets [the suture of the other side] in the mid-line beween the presphenoid and mesethmoid parts of the common mesethmo-presphen. mass. I have shown it to Sir Arthur Keith, and he has no doubt that this little partial suture is the front part of the pre-orbitosphenoidal suture, and not a division between the presphenoid and mesethmoid. In an older young Indian Elephant, 'No. 2259' there is no indication left of this suture."

While it is impossible to express any but a very guarded opinion without having personally examined the specimen, I incline, from a comparison with the condition in the Hyrax (text-figure 9), to regard the suture as indicating not only the front of the pre-orbito-sphenoid mass, but a portion of the boundary between the presphenoid and the mesethmoid, If this be so, the

Text-figure 9.



Median section of Sknll of young *Procavia capensis*. Skull length 73 mm.

mesethmoid would in the middle line be a much larger element than the presphenoid. But as I show in the figure I give of the Hyrax this mesethmoid is also there larger than the presphenoid.

In the Royal College of Surgeons' Museum there is the skull of a young Dugong "No. 2695 Skull of young male." Concerning this skull Mr. Burne writes: "The bones are too much consolidated to show any original separations. As it is there is no indication of separation between the presphenoid and mesethmoid."

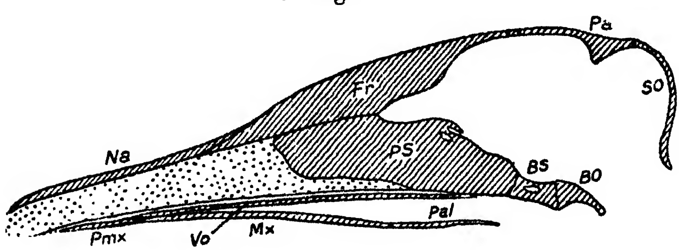
Edentata.

In my previous paper, I showed that *Orycteropus* has a distinct mesethmoid, and Mr. Burne confirms this from a young specimen in the Royal College of Surgeons' Museum. Of course, *Orycteropus* is not now regarded as an Edentate at all, and it by no means follows that the Sloths, Armadillos, and Anteaters are likely to agree in having a mesethmoid. In fact, there is some reason to believe that no mesethmoid will be found in the South American Edentates or the Pangolins. Unfortunately, a decided answer cannot be given to the question as to whether

a mesethmoid occurs. Kitchen Parker, in his great paper on the development of the skull in the Edentata, published in 1885, described the structure of the skull in a number of stages of young Armadillos, in four stages of young Sloths, in a couple of stages of the little Anteater of the genus *Cycloturus*, and in a number of stages of the Pangolin. In no single specimen did he meet with a distinct mesethmoid. In the majority of his specimens the internasal cartilage he found quite unossified.

In the Royal College of Surgeons' Museum there are no specimens that conclusively settle the question. In adult skulls of Armadillos and Anteaters the presphenoid and mesethmoid form a continuous mass without any indications of separation. In one skull of *Dasypus sexcinctus* Mr. Burne says "the presphenoid and mesethmoid form a continuous mass showing on the intercranial surface diagonal presph.-orbitosphenoidal sutures very similar to those present in the young African Elephant." Mr. Burne has sent me figures, but these differ from those in the young Elephant in not coming to the middle line. So that to me it would appear that the sutures are between the

Text-figure 10.



Median section of Skull of young *Tatusia* sp. (Am. Mus. 70416.)

orbitosphenoids and the ethmoturbinals, while the presphenoid in the middle line is uninterruptedly continued into the mesethmoid region.

In my own collection I have only two specimens that are of any assistance in the matter. One is a young *Tatusia* corresponding to Parker's 5th Stage. In it the mesethmoid region is just beginning to ossify apparently in continuation with the presphenoid. The specimen, however, is just a little too young to be completely convincing.

The other specimen I have is a young *Cycloturus* sp. (text-figure 6) at nearly the same stage of development as the one figured by Parker (pl. x. fig. 7). The basioccipital, the basisphenoid, and the presphenoid are all well ossified, but there is as yet no ossification in the mesethmoid region. As, however, the presphenoid ossification is relatively appreciably larger than in Parker's specimen, it seems as if the ossification is invading the

mesethmoid region. Still, as in the Armadillo, the specimen is a little too young to completely prove the case.

At present all that can be said is that no one apparently has ever seen an independent mesethmoid in an Edentate, and the evidence, so far as it goes, is in favour of there being none.

Menotyphla.

In view of the facts that the Menotyphla have a Jacobson's Organ of the Marsupial type, and in some other respects are primitive and yet are most probably the ancestors of the Lemurs, Bats, and Apes in which mesethmoids are developed, it became a matter of much interest to see if a mesethmoid occurs in the Menotyphla. Fortunately, I have a young specimen of *Macroscelides rupestris* sufficiently old to have all the basicranial elements well ossified, and yet young enough to show them all distinct. As will be seen from the figure I give (text-figure 7), there is a large independent mesethmoid as in most higher mammals, and not only is it an autogenous element, but in the middle line it is larger than any of the other basicranial bones. It is very interesting that the Menotyphla with a marsupial-like Organ of Jacobson have a higher mammal-like basicranial axis; while the other "Insectivorous" group, the Chrysochloridea, which has a marsupial-like Organ of Jacobson, still retains the marsupial-like basicranial axis.

Chiroptera.

The only specimen of the Chiroptera which I at present have of suitable age to show if there is an independent mesethmoid is a young Fruit-Bat, *Epomophorus wahlbergi*, about two-thirds grown. This specimen was given me a couple of years ago by Mr. John Havill, of the Albany Museum, Grahamstown.

When a median section of the skull was made (text-figure 8), it was found that the basicranial axis is closely similar to what we find in *Macroscelides*, and that there is a large independent mesethmoid.

Hyracoidea.

In my previous paper I mentioned that the condition of the basicranial axis in *Procavia* is quite unlike what we find in Ungulates, and that there is a large independent mesethmoid. It seems worth while giving a figure of the condition (text-figure 9).

Conclusion.

While it may be some time before we can know the condition of the basicranial elements in all the living mammalian groups, and certainly many years before we can know much of the development in extinct forms, we already know enough to see that the condition of the basicranial axis is of much importance in classification.

There appears to be little doubt that there is no mesethmoid

bone developed in Monotremes, and pretty certainly there is none in Marsupials. In the higher mammals we find there are many Orders in which a large mesethmoid is invariably present developed from an autogenous centre. This is the condition in the Primates, Chiroptera, Dermoptera, and Menotyphla, and we have reason to believe that these are all related and form a natural group. The same condition is found in the Insectivora, the Carnivora, the Rodentia, the Hyracoidea, and the Tubulidentata. But while the Insectivora and the Carnivora are probably closely related we know very little of the affinities of the Rodentia, the Hyracoidea, and the Tubulidentata.

We might readily divide the Eutheria into two groups, those without a mesethmoid and those with one, and if we could be sure that all mammals with a mesethmoid had sprung from a common ancestor, and that when a mesethmoid is once developed it is never again lost in a descendant, the classification would be a good one. But it is not at all improbable that a mesethmoid has been developed independently in more than one group. Still, whether further evidence allows us to subdivide the Eutheria on the presence or absence of a mesethmoid, there is no doubt that the condition of the anterior part of the basicranial axis is of much importance, and will have to be carefully considered in all future classification of the Higher Mammals.

Addendum (21.2.27):—I have just received to-day from Prof. W. K. Gregory, of New York, the loan of a skull of an adolescent *Tatusia* from the collection of the American Museum. Dr. Gregory has most carefully cut the skull almost in the middle line so that the condition of the basicranial axis can be very clearly seen. The skull measures 95 mm. in length, and though thus nearly adult is sufficiently young to have all the cranial sutures patent.

From this skull (text-figure 10) it is quite manifest that there are, as in Marsupials, only three bones in the basicranial axis. The basioccipital is quite a small bone, and the basisphenoid even shorter. In front of the basisphenoid is a single large bone which is manifestly the presphenoid. From the condition seen in the younger Armadillo skull which I have been able to examine, the presphenoid ossifies fairly early and the ossification extends into the mesethmoid region. Whether the cribriform plate is ossified as in the Artiodactyls from the turbinal is at present unknown, but apparently from the crista the ossification extends backwards and outwards to meet the orbito-sphenoid, and a suture is seen between the two at the sides but not in the median region.

As we have this satisfactory evidence that the Armadillo agrees with the Marsupials in having no mesethmoid bone, we seem now justified in definitely dividing the Eutheria into two groups—those with a mesethmoid bone and those without. The primitive group may be called the Palæotherida and the higher

group the Neotherida; and the Monodelphia or Eutheria divided thus:—

Subclass MONODELPHIA.

Superorder PALÆOTHERIDA.

Order Xenarthra.
? Order Pholidota.
Order Artiodactyla.
Order Perissodactyla.
Order Chrysochloridea.
Order Cetacea.

Superorder NEOTHERIDA.

Order Tubulidentata.
Order Hyracoidea.
Order Rodentia.
Order Insectivora.
Order Carnivora.
Order Menotyphla.
Order Chiroptera.
Order Dermoptera.
Order Primates.

Too little is known of the development of extinct forms to admit at present of their being placed in their proper Superorders, though doubtless in time it will be possible to correctly classify most; and the development of some living groups is still imperfectly known, and for their classification we must also wait.

It is interesting to observe that the classification here given agrees strikingly closely with that proposed by Huxley in 1872, and founded for the most part on the placental condition. His classification is:—

MONODELPHIA.

(*a*) Median incisor teeth never developed in either jaw.

(1) Edentata.

(*b*) Median incisor teeth are almost always developed in one or both jaws.

(I.) The uterus develops no decidua (non-Deciduata).

(2) Ungulata.
(3) Toxodontia (?).
(4) Sirenia (?).
(5) Cetacea.

(II.) The uterus develops a decidua (Deciduata).

(α) The placenta is zonary.

(6) Hyracoidea.
(7) Proboscidea.
(8) Carnivora.

(β) The placenta is discoidal.

(9) Rodentia.
(10) Insectivora.
(11) Cheiroptera.
(12) Primates.

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ACINONYX REX, sp. n.

16. Description of a New Species of Cheetah (*Acinonyx*). By R. I. Pocock, F.R.S.

[Received February 22, 1927 : Read February 27, 1927.]

(Plate I.; Text-figures 6–8.)

In September 1926 Major A. L. Cooper, D.S.O., sent simultaneously to the Natural History Museum and to the office of 'The Field' a photograph of a large unidentified member of the Cat tribe which was trapped by natives in the Umvukwe Range, north-west of Salisbury, Rhodesia. This photograph, with Major Cooper's account of the animal, was published in 'The Field,' Oct. 14th, p. 690. In this account he spoke of the animal as obviously a hybrid between a leopard and a cheetah and described it as like a very stockily built leopard, with powerful limbs and a comparatively short thick tail, but with the non-retractile claws of the cheetah and a ruff round the neck, which is absent in the leopard, and with a pattern of stripes quite distinct from anything previously known.

The small photograph naturally did not show either the mane on the neck or the cheetah-like characters of the claws, and, when commenting on the great interest of Major Cooper's discovery ('The Field,' Oct. 28th), I dismissed as too improbably true for discussion the view that the animal was a leopard-cheetah hybrid, and suggested that it was probably an aberrant leopard—a species which is known to vary occasionally to a very remarkable degree in its pattern, although admittedly no leopard's skin marked like the skin that interested Major Cooper had been previously recorded.

So convinced, however, was Major Cooper that the animal was not an aberrant leopard that he sent the skin to the Natural History Museum for inspection, and the most superficial examination of its feet showed me at once, firstly, that he was perfectly right in rejecting my suggestion, and, secondly, that the skin is that of an undescribed species of Cheetah.

Before giving in detail my reasons for this determination, I will quote the substance of some further particulars about the animal contained in Major Cooper's letter accompanying the skin, which was obtained from the natives by Mr. Donald Fraser, who kindly presented it to the Pretoria Museum.

As a result of his inquiries from all possible sources, native as well as European, Major Cooper has ascertained that this skin is by no means the only one known. A second, in the possession of Mr. Lacey, of Salisbury, was taken from an animal killed by natives in the Siki Reserve, about 25 miles south of Salisbury, in May 1926. It resembles the first in the structure of its claws and, as the photograph of it forwarded by Major Cooper clearly shows, in the presence of the mane and the style of its pattern.

By Mr. Jackson, Assistant Chief Native Commissioner, a keen naturalist who has probably had more opportunity of studying the fauna of the country for the last thirty years than anyone else, Major Cooper was told that many years ago these animals were fairly common and, for want of a better name, were called Mazoe leopards. He saw a skin similar to the two above mentioned at the Mutembara Mission a considerable time ago. This animal was shot in the Melsetter District close to the Portuguese Border.

Two more specimens were shot in the Bikita District in June 1925, and are in the possession of a store-keeper there. This makes a total of five skins all alike and procured in different places at different times; and this, as Major Cooper remarks, "pretty well disposes of the theory of the skin being that of an aberrant animal."

The skin Major Cooper sent home for inspection was shown by Mr. Jackson to one of his head native police, who said he knew the animal well, that it was as large as a full-grown leopard or larger. Also he stated that it never attacked cattle or calves, but was very shy, and that the only harm it ever did was to take an occasional goat kid. The natives were not at all afraid of it as they were of leopards, and would attack it armed only with assegais: and that he could not remember ever having heard of one climbing up a tree. In conclusion, Major Cooper adds that since his account of this animal was published in 'The Field' he has received letters from various people on the continent and elsewhere stating that they know the skin well. One man informed him that it was the skin of an African Ocelot, and that he had handled many of them.

That is an epitome of the history of this animal down to the present time; and with the evidence now before us of its existence and of its distribution over a fairly large area of Rhodesia which has been occupied by Europeans for many years, it seems extraordinary, as Major Cooper remarks, that it was never mentioned by such keen observers as Selous, Van Niekerk, and others. Since there appears now to be no doubt that the animal is not a casual freak or hybrid, there seems to be no other conclusion than that it is an undescribed species, and my reasons for assigning it to the genus *Acinonyx*, of which only one species, *jubatus*, has hitherto been known, rest mainly upon the structure of the feet, which are in every particular identical with those of *A. jubatus* and differ entirely from those of leopards (*Panthera pardus*).

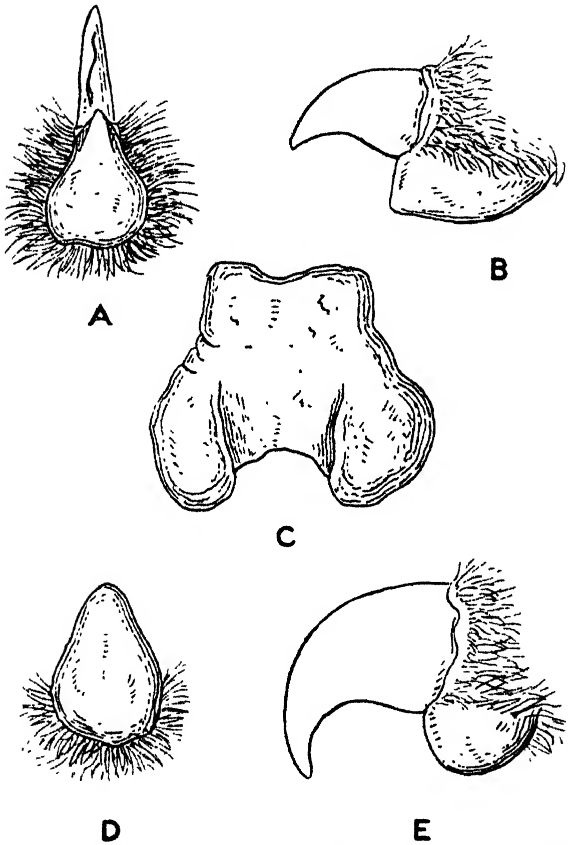
The differences between the feet of the two genera are as follows* (text-figs. 6 and 7, pp. 247 & 249):—

(1) In the cheetahs the claws of digits 2 to 5 are shorter and straighter. In the leopard these claws are longer and more hooked.

* See my paper "On some Cranial and External Characters of the Hunting Leopard or Cheetah (*Acinonyx jubatus*)." Ann. Mag. Nat. Hist. (8) xviii. p. 419 (1916).

(2) In the cheetah there are no flaps of skins on the digits to form protective sheaths for the claws when retracted. In the leopard, as in all the typical Felidæ, these flaps are invariably present.

Text-figure 6.



A. Lower side of pad and claw of 4th digit of fore foot of *Acinonyx rex*.
B. The same from the side.
C. Plantar pad of *Acinonyx rex*.
D. Carpal pad of the same.
E. Claw and pad of 1st digit (pollex) of the same.

(3) In the cheetah the pads of digits 2 to 5 are narrowed at the end and compressed to form a sharp vertical edge. In the leopard they are evenly rounded in front, the anterior being like the posterior end.

(4) In the cheetah the first digit (dew-claw) of the fore foot is provided with a claw which is considerably larger than the claws of the other digits and differs from them in shape, being strongly hooked and sharp, like the claw of a leopard's foot. In the leopard this claw is a little smaller than the others and similar to them in shape.

(5) In the cheetah the plantar pad is much narrower, and its two posterior lobes are somewhat compressed so as to form two shallow, superficial, longitudinal ridges. In the leopard this pad is broader and flatter, and its two posterior lobes are low, uncompressed, show no trace of a ridge, being merely defined by shallow grooves.

(6) In the cheetah the carpal pad is horny, markedly piriform, with a narrowed, often pointed apex. In the leopard it is soft, more ovate, with a bluntly rounded apex.

All the above-mentioned characters distinguishing the feet of the common Cheetah (*Acinonyx jubatus*) from those of the Leopard (*Panthera pardus*) are very clearly shown upon the skin forwarded by Major Cooper, and prove conclusively that it represents a species of *Acinonyx* and not of *Panthera*. This conclusion is confirmed by several additional features in the skin, namely :—

(1) The presence of a thick mat of hairs, the mane, on the nape of the neck and reaching to a point between the shoulders, the hairs of the nape not being directed forwards. This is the case in the common cheetah, whereas in the leopard there is no such mane or mat, and the hairs on each side of the nape grow forwards from a whorl and converge towards the middle line to form a low longitudinal crest, as in the lioness and lion-cubs of both sexes.

(2) The hair upon the side of the head between the ear and the eye grows forwards, as in the common cheetah. In leopards it is directed backwards from the eye to the base of the ear, where there is a longish fringe of forwardly radiating hair.

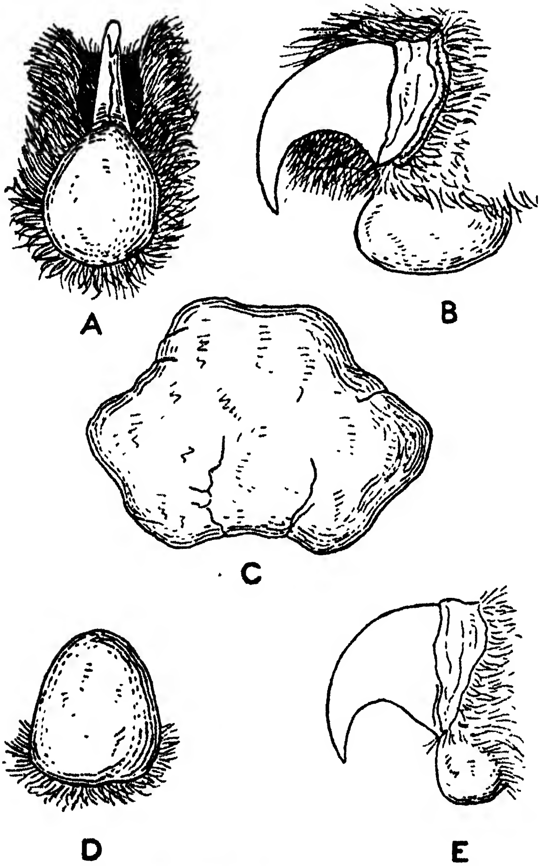
(3) The mystacial and superciliary vibrissæ are slender and the genal vibrissæ are slender or absent or, at least, not detectable. In the leopards the typical vibrissæ are always in evidence and comparatively long and rigid.

(4) On each side of the face there is a black stripe extending from the anterior corner of the eye to the mouth. This is always present in the common cheetah and never present in leopards.

(5) The white of the belly is unspotted, as in the common cheetah. In leopards it is as fully spotted as the flanks.

The differences above described between cheetahs and leopards in the development of the facial vibrissæ and the structure of the feet, may be explained by the differences between the two

Text-figure 7.



A. Lower side of pad and claw of 4th digit of fore foot of a Leopard (*Panthera pardus*).

B. The same from the side with the near half of the integumental sheath cut away.

C. Plantar pad of *Panthera pardus*.

D. Carpal pad of the same.

E. Claw and pad of 1st digit (pollex) of the same.

animals in predatory habits. The well-developed facial vibrissæ and the soft pliable feet of the leopard are alike adapted for stealthy stalking through jungle or bush, the final capture of the

quarry being effected by a sudden leap or short rush, when the sharp hooked claws are brought into action to lacerate or maintain a secure hold on the animal pounced upon. Such claws would become clogged if used for running any distance over soft ground or blunted or hard ground. The cheetah, on the other hand, habitually captures its prey by running it down in the open, often covering several hundred yards, six hundred is, I believe, the record run—before getting up to it. It takes advantage, it is true, of what cover there may be to get as near as possible before venturing into the open, but this mode of approach from a distance clearly does not call for the silence which is favoured by the facial vibrissæ and soft feet of the leopard; and in the case of the feet the shorter, straighter, blunter claws of the four main toes are adapted, like those of the dog, for securing a grip on the ground when the animal is going at speed; and for such claws sheaths would be a useles inconvenience. The sharp-edged digital pads, the compressed plantar pads, and the horny pointed carpal pad are mainly, I suspect, adaptations for checking the headlong course when a sudden turn after the quarry is necessary. But upon overtaking its victim the cheetah does not run into it and, like a dog, seize it with his jaws. He strikes it down with a blow of his fore foot. In this we find, I have no doubt, the explanation of the size, curvature, and sharpness of the claw of the first digit, which, resembling the claws of a leopard, would increase the efficacy of the final strike by inflicting a lacerating wound.

With the evidence above enumerated that the species must be assigned to *Acinonyx*, it may be fully described as follows:—

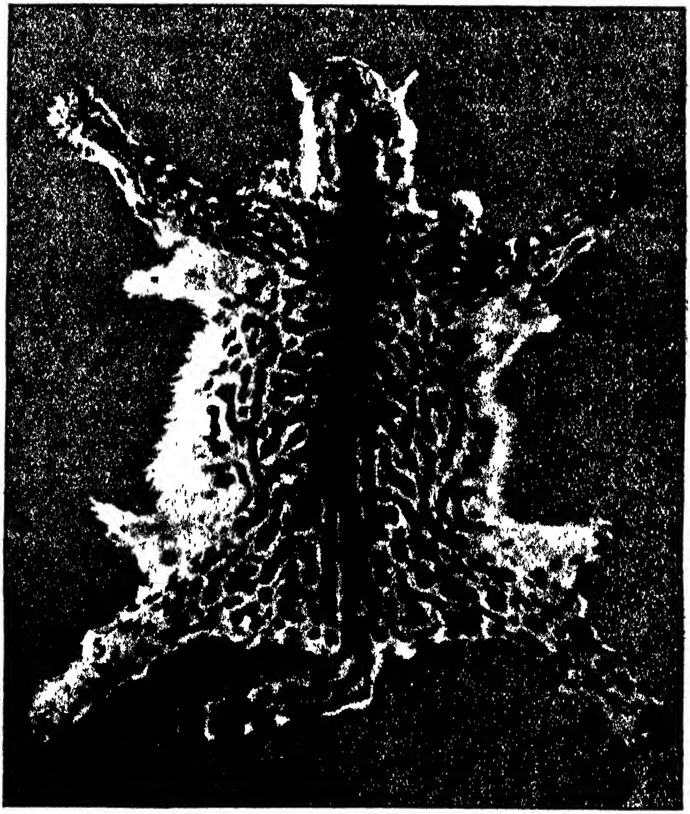
ACINONYX REX Pocock.

Acinonyx rex Pocock, Abstr. No. 283, Proc. Zool. Soc., March 1st, 1927, p. 18.

Distinguishable from *A. jubatus* by its pattern, which consists in the main of longer or shorter broad black stripes interspersed with blotches or spots of the same colour, the stripes upon the back behind the shoulders and on the proximal half of the tail being longitudinal, those on the sides transverse or oblique, and those low down, above the white of the belly, mostly longitudinal. On the back behind the shoulders there is a pair of longitudinal stripes extending backwards to the root of the tail and diverging posteriorly, the area between them being occupied by a median spinal stripe which may itself divide posteriorly. Anteriorly these two stripes converge and may coalesce to a greater or less extent; but they are traceable over the neck up to the head. In the thoracic region short stripes, transverse or oblique, pass outwards from them, and posteriorly another longitudinal stripe, more or less broken up and branched, lies alongside them. On the sides the stripes are very irregular in length and shape, being branched or looped, or hooked, and often appearing to

be formed by the confluence of spots or blotches. The head is marked with abbveviated stripes and spots on the forehead, and with spots upon the cheeks below the eyes and ears; there is a black stripe from the eye to the mouth, and the ears behind are black at the base. The legs are blotched and spotted to the feet. The tail in its proximal half has two longitudinal stripes,

Text-figure 8.



Photograph of the flat skin of the type specimen of *Acinonyx rex*.

irregular in size and shape; but in its distal half it is marked with broad, irregular, transverse, black stripes separated by narrower pale stripes. The ground-colour is mostly cream-buff contrasting very forcibly with the blackness of the pattern, but the dorsal area is tinted with ashy grey. The hind leg below the hock is pale buff, not ashy as in most skins of *A. jubatus*.

The pattern differs in details in the two skins, of which

Major Cooper sent the photographs, and also on the right and left sides of the individual skins.

The dimensions of the two in English inches are approximately as follows :—

	Head and Body.	Tail.
The skin sent by Major Cooper ...	4 ft. 2 in.	2 ft. 6 in
Mr. Lacey's skin	4 ft. 5 in.	2 ft. 6 in.

These dimensions correspond very closely with those recorded for *Acinonyx jubatus*; and upon comparing the skin sent by Major Cooper with a similarly prepared skin of *A. jubatus* from the Transvaal, presented to the British Museum by Mr. C. H. B. Grant, I can find no evidence that *Acinonyx rex* is a more "stockily" built animal than *Acinonyx jubatus.*

It is possible that the skull, which is at present unknown, may show other differences between the two species than those above recorded.

In conclusion, it may be added that there are two possible interpretations of the pattern of *A. rex.* The first is that it has been derived from the pattern of *A. jubatus* by the coalescence of the spots into stripes and blotches. In that case *A. rex* would be regarded as a specialized derivative form of *A. jubatus.* On the other hand, it must be remembered that there is a good deal of evidence in favour of the view that the pattern of the Felidæ consisted originally of broad longitudinal stripes which subsequently became broken up into chains of spots. At a later stage the spots became arranged in rosettes, as in the leopard and jaguar, or irregularly scattered as in the common cheetah (*A. jubatus*), the final stage being the coalescence of the spots or rosettes to form transverse stripes. If this theory of the evolution of the pattern in the Felidæ be true, the pattern of *Acinonyx rex* may be interpreted as representing a much more primitive type than that of *A. jubatus.* There, for the present, the matter must be left. Possibly the pattern of the cubs of *A. rex*, when known, may throw some light on the question; but it may be noted that the pattern of the cubs of *A. jubatus* is not like that of the adult of *A. rex*, but, so far as it is observable in the long hair which clothes the body, it consists of spots like those of the full-grown individuals of *A. jubatus.*

EXHIBITIONS AND NOTICES.

February 8th, 1927.

Prof. E. W. MacBride, M.A., D.Sc., F.R.S., Vice-President, in the Chair.

The Secretary read the following Report on the Additions to the Society's Menagerie during the months of November and December, 1926, and January, 1927:—

November, 1926.

The registered additions to the Society's Menagerie during the month of November were 77 in number. Of these 49 were acquired by presentation, 5 were deposited, 9 were purchased, and 14 were born in the Menagerie.

The following may be specially mentioned:—

1 Striped Hyæna (*Hyæna hyæna*), from West Africa, presented by R. L. A. Underwood on November 8th.

2 Capybaras (*Hydrochœrus hydrochœrus*), from South America, presented by Lieut. A. M. Hughes, R.N., on November 18th.

1 Albino Sooty Mangabey (*Cercocebus fuliginosus*), from West Africa, deposited on November 30th.

December.

The registered additions to the Society's Menagerie during the month of December were 211 in number. Of these 118 were acquired by presentation, 9 were deposited, 66 were purchased, and 18 were born in the Menagerie.

The following may be specially mentioned:—

A Wild Cat (*Felis sylvestris*), from Ross-shire, presented by Sir Alexander Gibb, G.B.E., C.B., F.Z.S., on December 1st.

A Tiger Cub (*Felis tigris*), from the Central Provinces of India, presented by W. H. Shoobert, I.C.S., on December 6th.

A European Bison (*Bison bonasus*), from Central Europe, presented by His Grace the Duke of Bedford, K.G., F.R.S., on December 13th.

A collection of reptiles, including 43 Soft-shelled Tortoises (*Testudo loveridgii*), from Tanganyika Territory, presented by Arthur Loveridge, C.M.Z.S., on December 18th.

1 Coral-bellied Snake (*Aporophis coralliventris*), from Uruguay, new to the Collection, presented by C. R. Barry on December 15th.

A collection of North-American reptiles, including a Carolina Engystoma (*Engystoma carolinense*), new to the Collection, purchased on December 10th.

18 Anacondas (*Eunectes murinus*), born in the Gardens on December 11th.

JANUARY, 1927.

The registered additions to the Society's Menagerie during the month of January were 84 in number. Of these 73 were acquired by presentation, 5 were purchased, and 6 were born in the Menagerie.

The following may be specially mentioned :—

1 African Wart Hog (*Phacochœrus æthiopicus*), from West Africa, presented by David Jones, Esq., on January 3rd.

1 Markhoor (*Capra megaceros*), from N.W. India, presented by Col. B. Abbay on January 11th.

1 Arctic Hare (*Lepus arcticus bangsi*), from Newfoundland, presented by Capt. J. C. Jackson on January 8th. New to the Collection.

1 Pluto Monkey (*Cercopithecus leucampyx*), and 1 Schmidt's Monkey (*C. schmidti*), from Angola, presented by R. Murray Hughes, Esq., on January 10th.

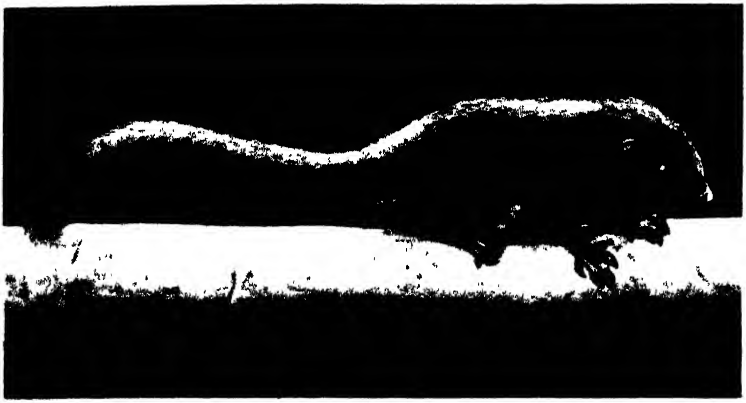
1 Prejevalski's Wild Horse (*Equus prejevalskii*), presented by His Grace the Duke of Bedford, K.G., F.R.S., on January 26th.

1 Pesquet's Parrot (*Dasyptilus pesqueti*), from New Guinea, presented by J. Spedan Lewis, Esq., on January 24th.

A collection of Penguins from the Falkland Islands, consisting of 8 King Penguins (*Aptenodytes patagonica*), 4 Rock-hopper Penguins (*Catarrhactes chrysocome*), and 4 Gentoo Penguins (*Pygosceles papua*), presented by the Government of the Falkland Islands on January 26th.

Dr. W. E. LE GROS CLARK, F.R.C.S., F.Z.S., exhibited a series of Photographs of the Tree-Shrew (*Tupaia minor*) (Plate I.), and made the following remarks thereon :—

During the past few years, evidence has been accumulating in support of the suggestions entertained by many anatomists that the Tupaiidæ represent structural links between the Insectivora and Lemuroidea. In his latest publication (Amer. Journ. of Physical Anthropology, Oct. 1926, p. 415), Gregory remarks: "The existing Tree-Shrews (Tupaiidæ) of Borneo and adjacent regions seem to be living and but little modified survivors of the basal Primate stock, so that after many studies on their anatomy and osteology certain authors classify them as the first division of the Primates rather than as a highly progressive family of Insectivores." In an earlier work, this author points out that the question of the inclusion of the Tupaiidæ in the order



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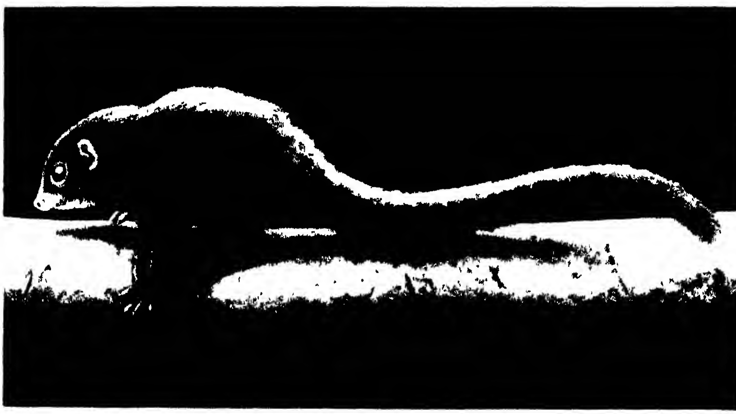

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TUPAIA MINOR.

Primates is largely a matter of definition. However this may be, it is certain that the Tree-Shrews represent a highly important group of mammals, and, for this reason, they demand an intensive study from all aspects.

Tupaia minor is one of the smaller tree-shrews, and it is less specialized in regard to general proportions of the body, development of the tail, and colouring, than most other members of the family. In appearance the animal gives an impression of alertness and agility and is remarkably squirrel-like. It has a relatively restricted geographical distribution, being confined to Borneo, Sumatra, and the Malay Peninsula. It would appear that *Tupaia minor* is more thoroughly arboreal in its habits than larger species such as *Tupaia ferruginea*, which Wood-Jones regards rather as a bush animal. I have encountered specimens of the former springing along the upper branches of high trees and also running about the undergrowth. It is interesting in this connection to note Wood-Jones's observation that if squirrels and Tupaias are met in the undergrowth, the squirrels take to the trees when alarmed, but the tree-shrews make for the ground. The nesting habits of *Tupaia minor* have been referred to by Charles Hose. That this animal is diurnal in its habits is indicated by my own observations on the tree-shrew in the wild state while I was in Borneo, and also by the structure of the retina, which corresponds with the type associated with this mode of vision.

Although the tree-shrews are not rare, there are, as far as I know, practically no good photographs of the living animal available for study. One photograph, which I myself took, has been published in Elliot Smith's 'Essays on the Evolution of Man.' The photographs which are here reproduced were sent to me by Mr. Banks, the Curator of the Government Museum of Sarawak. Enlargements of the original photographs were made, and these have been prepared for publication by Mr. A. K. Maxwell, who has, under my direction, slightly accentuated certain features of the digits which otherwise would have been obscured in the process of reproduction. The photographs illustrate an immature specimen of *Tupaia minor*. They illustrate, among other points, the moderately developed snout, the relatively large eyes, and the small and degenerate ears which are characteristic of this animal. An examination of the digits indicates their free divergence and a definite tendency to opposability of the pollex and hallux. In my own photograph of the adult animal, referred to above, the pollex can be seen to be clearly opposed to the remaining digits in the act of grasping a branch. The functional differentiation of the hallux appears to be even more marked in the Pen-tailed Tree-shrew (*Ptilocercus lowii*), for in this animal the metatarsal element of this digit is conspicuously shorter and stouter than the other metatarsals. In *Tupaia minor* this structural specialization is not present. Also, the metatarsus as a whole is, proportionately to the length

of the pes, much longer than in *Ptilocercus*, and herein the latter is evidently more primitive. It is perhaps relevant here to note another feature which indicates a relative functional independence of the pollex and hallux in *Ptilocercus*. In one of my specimens of this rare animal the claws on these particular digits have been worn down to small blunt stumps, which have the appearance of stunted nails, contrasting strongly with the sharp and prominent claws of the other digits.

The photographs show that in this immature tree-shrew the tail is faintly ringed by alternate light and dark bands. I have previously recorded a similar marking on the tail of young Tarsiers.

February 22nd, 1927.

Sir A. Smith Woodward, F.R.S., Vice-President, in the Chair.

Lord Rothschild exhibited a mounted specimen of *Varanus komodensis*, the so-called "Dragon" of Komodo Island, Dutch East Indies. He also exhibited for comparison mounted examples of *Varanus salvator*, *Varanus albigularis*, and *Varanus rugicollis*. He said much had lately been written about this, the largest of the lizards, but most of the statements were much exaggerated. The type-specimen was recorded as 13 feet in length, but in reality it is just 12 feet 4 inches. None now alive on the Island exceed 10 feet in length, but their bulk is very considerable. The interesting feature of the Komodo Monitor, apart from its bulk, lies in its relationship. The 22 other Indo-Australian species all have smooth scales, with one exception, tails much longer than the body, and narrow heads; *V. komodensis*, on the other hand, has the scales much raised with a central keel, a comparatively short tail, and a broad blunt head; in these respects it resembles the much smaller West African Lace-Lizard, *Varanus albigularis*. The only Indo-Australian *Varanus* showing raised scales, and these on the hind neck only, is *Varanus rugicollis* of Borneo, which is exhibited to-night, but this is a quite small and slender species. *Varanus salvator* of Western Malayasia and *V. giganteus* of New Guinea come near to *V. komodensis* in length, examples nearly reaching 8 feet being on record; but they neither ever approach this species in bulk, a 10-foot specimen of which weighed alive 3 cwt.

Major C. M. Ingoldby, R.A.M.C., F.L.S., F.Z.S., exhibited, and made remarks upon, a series of specimens illustrating Climatic Phases of some African Squirrels (Genus *Heliosciurus*).

Mr. R. I. POCOCK, F.R.S., F.Z.S., gave an account of a new species of Cheetah, based upon a skin from the Umvukwe Range, N.W. of Salisbury, Rhodesia, which was sent to the British Museum (Natural History) by Major A. L. Cooper, D.S.O. The species was named and diagnosed as follows:—

Acinonyx rex, sp. n.

"Distinguishable from *A. iubatus* by its bold pattern of black stripes and blotches, which are longitudinal on the dorsal area and oblique or longitudinal upon the flanks."

March 8th, 1927.

Prof. E. W. MACBRIDE, M.A., D.Sc., F.R.S., Vice-President, in the Chair.

Prof. E. B. POULTON, F.R.S., F.Z.S., exhibited, and made remarks upon, a series of lantern-slides illustrating "Gynandromorphism in Butterflies following Shock to the Pupæ."

['Proceedings,' 1926, Part IV. (pp. 941–1314), was published on December 29th, 1926.]

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[New names in clarendon type. Systematic references in italics. (Z. S. L.) indicates additions to the Society's Menagerie.]

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No. 282.

ABSTRACT OF THE PROCEEDINGS

OF THE

ZOOLOGICAL SOCIETY OF LONDON *

February 8th, 1927.

Prof. E. W. MacBride, M.A., D.Sc., F.R.S., Vice-President, in the Chair.

The Secretary read a Report on the Additions to the Society's Menagerie during the months of November and December, 1926, and January, 1927.

Dr. W. E. Le Gros Clark, F.R.C.S., F.Z.S., exhibited, and made remarks upon, a series of photographs of a living Tree-Shrew (*Tupaia minor*).

Major S. S. Flower, O.B.E., F.Z.S., communicated his paper on "Loss of Memory accompanying Metamorphosis in Amphibians."

Dr. H. H. Woollard communicated his paper on "The Differentiation of the Retina in the Primates."

Dr. F. P. Stowell, B.Sc., Ph.D., A.I.C. (Aquarium Research Fellow), gave a *résumé* of his paper on the "Physical and Chemical Conditions in the Fresh-water Circulation of the Society's Aquarium."

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* This Abstract is published by the Society at its offices, Zoological Gardens, Regent's Park, N.W., on the Tuesday following the date of Meeting to which it refers. It will be issued, along with the 'Proceedings,' free of extra charge, to all Fellows who subscribe to the Publications; but it may be obtained on the day of publication at the price of *Sixpence*, or, if desired, sent post-free for the sum of *Six Shillings* per annum, payable in advance.

In the absence of the Authors, the following papers were taken as read :—OLDFIELD THOMAS, F.R.S., F.Z.S., "The Delacour Exploration of French Indo-China.—Mammals"; EDITH M. SHEPPARD, M.Sc., F.Z.S., "Revision of the Family Phreatoicidæ (Crustacea) with a Description of Two new Species; CHI PING, "On the Structures of the Hard Palate of *Felis tigris*"; ROBERT GURNEY, M.A., F.Z.S., "Some Australian Fresh-water Entomostraca reared from Dried Mud."

The next Meeting of the Society for Scientific Business will be held on Tuesday, February 22nd, 1927, at 5.30 P.M., when the following Communications will be made :—

Lord ROTHSCHILD, F.R.S., F.Z.S.

Exhibition of a Mounted Example of the "Dragon" (*Varanus komodensis*), from Komodo Island, Dutch East Indies.

Major C. M. INGOLDBY, R.A.M.C., F.L.S., F.R.G.S., F.Z.S.

Exhibition of Specimens illustrating Climatic Phases of some African Squirrels (Genus *Heliosciurus*).

R. I. POCOCK, F.R.S., F.Z.S.

Exhibition of the Skin of a new Species of Cheetah.

MALCOLM SMITH, M.R.C.S., L.R.C.P., F.Z.S.

Contributions to the Herpetology of the Indo-Australian Region.

JAMES WATERSTON, B.D., D.Sc., F.Z.S.

A remarkable Scelionid (Hymenoptera-Proctotrypoidea) from South Africa.

Prof. ALEXANDER MEEK, D.Sc., F.Z.S.

Bipinnaria asterigera (Echinodermata) from the Northumberland Plankton.

R. I. Pocock, F.R.S., F.Z.S.

The External Characters of the South African Striped Weasel (*Pœcilogale albinucha*).

W. B. Benham, D.Sc., F.R.S., F.Z.S.

External Sexual Differences in the Terebellid Worms.

A Collection of Papers by the following Authors, dealing with the Results of the Cambridge Expedition to the Suez Canal, 1924:—Pierre Fauvel; W. A. Thorpe; Oskar Carlgren; W. T. Calman; R. Gurney; V. C. Robinson.

The following Papers have been received:—

Dr. H. H. Scott, M.D., F.R.S.(Edin.), D.P.H., F.Z.S.

Report on the Deaths occurring in the Society's Gardens during the year 1926.

Prof. D. M. S. Watson, F.R.S., F.Z.S.

The Reproduction of the Cœlacanth Fish *Undina*.

Dr. R. Broom, F.R.S., C.M.Z.S.

(1) On a new Type of Mammal-like Reptile from the South African Karoo Beds.

(2) Some further Points on the Structure of the Mammalian Basicranial Axes.

N. S. Lucas, M.B., F.Z.S., E. M. Hume, and H. H. Smith.

On the Breeding of the Common Marmoset (*Hapale jacchus* Linn.) in Captivity when irradiated with Ultra-Violet Rays.

Daphne Atkins, B.Sc.

Report on the Myzostomida collected by Mr. F. A. Potts in Torres Strait, together with a Description of a Species obtained by Prof. J. Stanley Gardiner from the Maldives.

Oldfield Thomas, F.R.S., F.Z.S.

On Mammals from the Gobabis District of Eastern Damaraland, South-West Africa, obtained during Capt. Shortridge's Fourth Percy Sladen and Kaffrarian Museum Expedition. With Field-notes by the Collector.

EDITH BERKELEY.

A new Genus of Chætopteridæ from the N.E. Pacific: with some Remarks on allied Genera.

STANLEY HIRST, F.Z.S.

Note on Acari, mainly belonging to the Genus *Spinturnix* von Heyden.

MARJORIE E. SHAW, M.Sc.

On a Collection of Sponges from Maria Island, Tasmania.

R. I. POCOCK, F.R.S., F.Z.S.

The External Characters of the Bush-Dog (*Speothos venaticus*) and of the Maned Wolf (*Canis jubatus*).

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Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,
Secretary, Zool. Soc.

ZOOLOGICAL SOCIETY OF LONDON,
REGENT'S PARK, LONDON, N.W. 8.
February 15th, 1927.

No. 283.

ABSTRACT OF THE PROCEEDINGS

OF THE

ZOOLOGICAL SOCIETY OF LONDON.*

February 22nd, 1927.

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Dr. W. T. Calman, F.R.S., F.Z.S., gave a brief account of the work included in a collection of Papers by the following Authors, dealing with the Results of the Cambridge Expedition to the Suez Canal, 1924:—Pierre Fauvel; W. A. Thorpe; Oskar Carlgren; W. T. Calmam; R. Gurney; V. C. Robinson.

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The next Meeting of the Society for Scientific Business will be held on Tuesday, March 8th, 1927, at 5.30 P.M., when the following Communications will be made:—

Prof. E. B. POULTON, F.R.S., F.Z.S.

Gynandromorphism in Butterflies following Shock to the Pupæ.

Dr. H. H. SCOTT, M.D., F.R.C.P., F.R.S. (Edin.), D.P.H., F.Z.S.

Report on the Deaths occurring in the Society's Gardens during the year 1926.

Prof. D. M. S. WATSON, F.R.S., F.Z.S.

The Reproduction of the Cœlacanth Fish *Undina*.

Dr. R. BROOM, F.R.S., C.M.Z.S.

(1) On a new Type of Mammal-like Reptile from the South African Karoo Beds.

(2) Some further Points on the Structure of the Mammalian Basicranial Axes.

N. S. LUCAS, M.B., F.Z.S., E. M. HUME, and H. H. SMITH.

On the Breeding of the Common Marmoset (*Hapale jacchus* Linn.) in Captivity when irradiated with Ultra-Violet Rays.

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OLDFIELD THOMAS, F.R.S., F.Z.S.

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The External Characters of the Bush-Dog (*Speothos venaticus*) and of the Maned Wolf (*Canis jubatus*).

Cyril Crossland, M.A., D.Sc., O.N., F.Z.S.

The Expedition to the Pacific of the S.Y. 'St. George.'—Marine Ecology and Coral Formations in the Panama Region, Galapagos and Marquesas Islands, and the Atoll of Napuka.

F. P. Stowell, B.Sc., Ph.D., A.I.C., and V. P. Clancey.

Microscopical and Bacteriological Investigation of the Water in the Society's Aquarium.

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Secretary, Zool. Soc.

Zoological Society of London,
Regent's Park, London, N.W. 8.
March 1st, 1927.

No. 284.

ABSTRACT OF THE PROCEEDINGS

OF THE

ZOOLOGICAL SOCIETY OF LONDON.*

March 8th, 1927.

Prof. E. W. MACBRIDE, M.A., D.Sc., F.R.S., Vice-President, in the Chair.

Prof. E. B. POULTON, F.R.S., F.Z.S., exhibited and made remarks upon, a series of lantern-slides illustrating Gynadromorphism in Butterflies following Shock to the Pupæ.

Dr. H. H. SCOTT, M.D., F.R.C.P., F.Z.S. (Pathologist to the Society), communicated his Report on the Deaths occurring in the Society's Gardens during the year 1926.

Prof. D. M. S. WATSON, F.R.S., F.Z.S., communicated his paper on "The Reproduction of the Cœlacanth Fish *Undina*."

Prof. D. M. S. WATSON, F.R.S., F.Z.S., gave a *résumé* of the two following papers by Dr. R. BROOM, F.R.S., C.M.Z.S.:—(1) "On a new Type of Mammal-like Reptile from the South African Karoo Beds"; (2) "Some further Points on the Structure of the Mammalian Basicranial Axes."

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A paper on "The Breeding of the Common Marmoset (*Hapale jacchus* Linn.) in Captivity when irradiated with Ultra-Violet Rays," by N. S. LUCAS, M.B., F.Z.S., E. M. HUME, and H. H. SMITH, was communicated by Mr. N. LUCAS.

The next Meeting of the Society for Scientific Business will be held on Tuesday, March 22nd, 1927, at **5.30** P.M., when the following Communications will be made:—

THE SECRETARY.

Report on the Additions to the Society's Menagerie during the month of February, 1927.

G. C. ROBSON, M.A., F.Z.S.

Seasonal and Sexual Dimorphism in the Squid *Alloteuthis subulata*.

DAPHNE ATKINS, B.Sc.

Report on the Myzostomida collected by Mr. F. A. Potts in Torres Strait, together with a Description of a Species obtained by Prof. J. Stanley Gardiner from the Maldives.

OLDFIELD THOMAS, F.R.S., F.Z.S.

On Mammals from the Gobabis District of Eastern Damaraland, South-West Africa, obtained during Capt. Shortridge's Fourth Percy Sladen and Kaffrarian Museum Expedition. With Field-notes by the Collector.

F. P. STOWELL, B.Sc., Ph.D., A.I.C., and V. P. CLANCEY.

Microscopical and Bacteriological Investigation of the Water in the Society's Aquarium.

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R. I. POCOCK, F.R.S., F.Z.S.

The External Characters of the Bush-Dog (*Speothos venaticus*) and of the Maned Wolf (*Canis jubatus*).

J. BEATTIE, M.B., M.Sc., C.M.Z.S. (Anatomist to the Society).

The Anatomy of the Marmoset, *Hapale jacchus* Linn.

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ZOOLOGICAL SOCIETY OF LONDON,
REGENT'S PARK, LONDON, N.W. 8.
March 15*th*, 1927.

No. 285.

ABSTRACT OF THE PROCEEDINGS

OF THE

ZOOLOGICAL SOCIETY OF LONDON.*

March 22nd, 1927.

Sir ARTHUR SMITH WOODWARD, F.R.S., Vice-President, in the Chair.

The SECRETARY read a Report on the Additions to the Society's Menagerie during the month of February, 1927.

Dr. J. BEATTIE, C.M.Z.S. (Anatomist to the Society), exhibited, and made remarks upon, a series of Radiographs and Skulls showing the eruption of the permanent Dentition in the Chimpanzee and other Primates.

Mr. F. MARTIN DUNCAN, F.Z.S. (Librarian), exhibited, and made remarks upon, a series of Cinematograph Films he had taken in the Society's Gardens.

Mr. G. C. ROBSON, M.A., F.Z.S., exhibited specimens, and made remarks upon, the Seasonal and Sexual Dimorphism in the Squid *Alloteuthis subulata*.

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A paper on the "Microscopical and Bacteriological Investigation of the Water in the Society's Aquarium," by F. P. STOWELL, B.Sc., Ph.D., A.I.C. (Aquarium Research Fellow), and V. P. CLANCEY, B.Sc., was communicated by Dr. STOWELL.

In the absence of the Authors, the following papers were taken as read:—OLDFIELD THOMAS, F.R.S., F.Z.S., "On Mammals from the Gobabis District of Eastern Damaraland, South-West Africa, obtained during Capt. Shortridge's Fourth Percy Sladen and Kaffrarian Museum Expedition. With Field-notes by the Collector"; DAPHNE ATKINS, B.Sc., "Report on the Myzostomida collected by Mr. F. A. Potts in Torres Strait, together with a Description of a Species obtained by Prof. J. Stanley Gardiner from the Maldives."

The next Meeting of the Society for Scientific Business will be held on Tuesday, April 5th. 1927, at **5.30** P.M., when the following Communications will be made:—

E. G. BOULENGER, F.Z.S.

Exhibition of Photograph of a Crab with abnormal claw.

J. BEATTIE, M.B., M.Sc., C.M.Z.S. (Anatomist to the Society).

The Anatomy of the Marmoset, *Hapale jacchus* Linn.

Dr. H. H. WOOLLARD.

On the Brain of the Marmoset, *Hapale jacchus* Linn.

Major R. W. G. HINGSTON, I.M.S.

Protective Devices in Spiders' Snares.

The following Papers have been received :—

EDITH BERKELEY.

A new Genus of Chætopteridæ from N.E. Pacific: with some Remarks on allied Genera.

STANLEY HIRST.

Note on Acari, mainly belonging to the Genus *Spinturnix* von Heyden.

MARJORIE E. SHAW, M.Sc.

On a Collection of Sponges from Maria Island, Tasmania.

R. I. POCOCK, F.R.S., F.Z.S.

The External Characters of the Bush-Dog (*Speothos venaticus*) and of the Maned Wolf (*Canis jubatus*).

The Publication Committee desire to call the attention of those who propose to offer Papers to the Society, to the great increase in the cost of paper and printing. Papers should by condensed and be limited so far as possible to the description of new results.

Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,

Secretary, Zool. Soc.

ZOOLOGICAL SOCIETY OF LONDON,
REGENT'S PARK, LONDON, N.W. 8.
March 29th, 1927.

No. 286.

ABSTRACT OF THE PROCEEDINGS

OF THE

ZOOLOGICAL SOCIETY OF LONDON.*

April 5th, 1927.

Sir SIDNEY F. HARMER, K.B.E., F.R.S., Vice-President, in the Chair.

The SECRETARY exhibited, and made remarks upon, (1) the two volumes of the completed "World List of Scientific Periodicals," and (2) the first number of the American "Biological Abstracts."

Mr. E. G. BOULENGER, F.Z.S., exhibited, and made remarks upon, a Crab with abnormal Claw.

Dr. J. BEATTIE, C.M.Z.S., Anatomist to the Society, communicated his paper on "The Anatomy of the Marmoset, *Hapale jacchus* Linn."

Dr. J. BEATTIE, gave a *résumé* of a paper by Dr. H. H. WOOLLARD on "The Brain of the Marmoset, *Hapale jacchus* Linn."

Major R. W. G. HINGSTON, I.M.S., communicated his paper on "Protective Devices in Spiders' Snares," illustrating it with a series of Lantern-slides.

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* This Abstract is published by the Society at its offices, Zoological Gardens, Regent's Park, N.W., on the Tuesday following the date of Meeting to which it refers. It will be issued, along with the 'Proceedings,' free of extra charge, to all Fellows who subscribe to the Publications; but it may be obtained on the day of publication at the price of *Sixpence*, or, if desired, sent post-free for the sum of *Six Shillings* per annum, payable in advance.

The next Meeting of the Society for Scientific Business will be held on Tuesday, April 26th, 1927, at **5.30** P.M., when the following Communications will be made:—

THE SECRETARY.

Report on the Additions to the Society's Menagerie during the month of March, 1927.

Sir A. SMITH WOODWARD, F.R.S., F.Z.S.

Exhibition of photographs of some Cretaceous Fishes from the Lebanon.

R. G. CANTI, M.D.

Exhibition of Cinematograph-films of Living-tissue Cultures showing Cell-division.

J. BEATTIE, M.B., M.Sc., C.M.Z.S. (Anatomist to the Society).

The Visceral Lymphatic Channels of the Catarrhinæ.

R. I. POCOCK, F.R.S., F.Z.S.

The External Characters of the Bush-Dog (*Speothos venaticus*) and of the Maned Wolf (*Canis jubatus*).

EDITH BERKELEY.

A new Genus of Chætopteridæ from the N.E. Pacific: with some Remarks on allied Genera.

STANLEY HIRST, F.Z.S.

Note on Acari, mainly belonging to the Genus *Spinturnix* von Heyden.

MARJORIE E. SHAW, M.Sc.

On a Collection of Sponges from Maria Island, Tasmania.

The following Papers have been received:—

Dr. R. BROOM, F.Z.S., C.M.Z.S.

On *Sphenosuchus*, and the Origin of the Crocodiles.

H. HAROLD SCOTT, M.D., F.R.C.P. (Lond.), F.Z.S.

(1) Neoplasm in an Indian Rhinoceros.
(2) Two Cases of Peritoneal Neoplasm (Endothelioma).

CECIL A. HOARE, B.Sc.

Schewiakoff's Keys for the Determination of the Holotrichous Ciliates.

Dr. C. A. NILSSON-CANTELL.

Some Barnacles in the British Museum (Natural History).

The Publication Committee desire to call the attention of those who propose to offer Papers to the Society, to the great increase in the cost of paper and printing. Papers should be condensed and be limited so far as possible to the description of new results.

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Secretary, Zool. Soc.

ZOOLOGICAL SOCIETY OF LONDON,
REGENT'S PARK, LONDON, N.W. 8.
April 12th, 1927.

No. 287.

ABSTRACT OF THE PROCEEDINGS

OF THE

ZOOLOGICAL SOCIETY OF LONDON.*

April 26th, 1927.

Sir A. SMITH WOODWARD, F.R.S., Vice-President, in the Chair.

THE SECRETARY read a Report on the Additions made to the Society's Menagerie during the month of March 1927.

Sir A. SMITH WOODWARD recalled the fact that the first-recorded scientific Meeting of the Zoological Society was held on April 25th, 1827. It was reported in *The Times* of April 27th, 1827. Dr. Joshua Brookes, the eminent anatomist, had been invited by "the noble directors of the Society" to lecture on his dissection of the body of an ostrich which had lived for two years at Windsor, and at death had been given to the Society by the King. Lord Auckland, Lord Stanley, Dr. Birkbeck, and many others were present. In his general remarks, Dr. Brookes said "the period had arrived when the science of natural history bade fair to reach a height in this country which would enable us to rival the establishments founded for its promotion abroad."

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Sir ARTHUR SMITH WOODWARD exhibited, and made remarks upon, a series of specimens and photographs of Cretaceous Fishes from the Lebanon.

Following a brief description of the experimental arrangements and procedure adopted, Dr. R. G. CANTI exhibited a Cinematograph Film showing (*a*) the growth of cells of the periosteum of the Chick Embryo in the following stages:—Vegetative cell and its internal structures, cell undergoing division and degeneration, and (*b*) of cells in cultures of malignant tissue (Jensen's Rat Sarcoma) showing their special character.

Mr. R. I. POCOCK, F.R.S., F.Z.S., communicated his paper on "The External Characteristics of the Bush-Dog (*Speothos venaticus*) and of the Maned Wolf (*Chrysocyon jubatus*)."

Mr. J. BEATTIE, M.B., M.Sc., C.M.Z.S. (Anatomist to the Society), gave a *résumé* of his paper on "The Viceral Lymphatic Channels of the Catarrhinæ."

In the absence of the Authors, the following Papers were taken as read:—EDITH BERKELEY, "A New Genus of Chætopteridæ from the N.E. Pacific; with some Remarks on allied Genera"; STANLEY HIRST, F.Z.S., "Note on Acari, mainly belonging to the Genus *Spinturnix* von Heyden"; MARJORIE E. SHAW, M.Sc., "On a Collection of Sponges from Maria Island, Tasmania."

The next Meeting of the Society for Scientific Business will be held on Tuesday, May 10th, 1927, at **5.30** P.M., when the following Communications will be made:—

Dr. R. BROOM, F.R.S., C.M.Z.S.

On *Sphenosuchus*, and the Origin of the Crocodiles.

Dr. H. H. SCOTT, M.D., F.R.C.P. (Lond.), F.Z.S.

(1) Neoplasm in an Indian Rhinoceros.
(2) Two Cases of Peritoneal Neoplasm (Endothelioma).

Cecil A. Hoare, B.Sc.

Schewiakoff's Keys for the Determination of the Holotrichous Ciliates.

F. P. Stowell, B.Sc., Ph.D., A.I.C., Aquarium Research Fellow.

The Resistance of certain Metals and Metallic Alloys to Corrosion and Solution by Sea-water.

The following Papers have been received:—

Dr. C. A. Nilsson-Cantell.

Some Barnacles in the British Museum (Natural History).

W. N. F. Woodland, F.Z.S.

A Revised Classification of the Tetraphyllidean Cestoda, with Descriptions of some Phyllobothriidæ from Plymouth.

P. Esben-Petersen.

New Species of Neuroptera Planipennia in British Collections.—IV.

The Publication Committee desire to call the attention of those who propose to offer Papers to the Society, to the great cost of paper and printing. Papers should be condensed and be limited so far as possible to the description of new results.

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P. CHALMERS MITCHELL,
Secretary, Zool. Soc.

Zoological Society of London,
Regent's Park, London, N.W. 8.
May 3rd, 1927.